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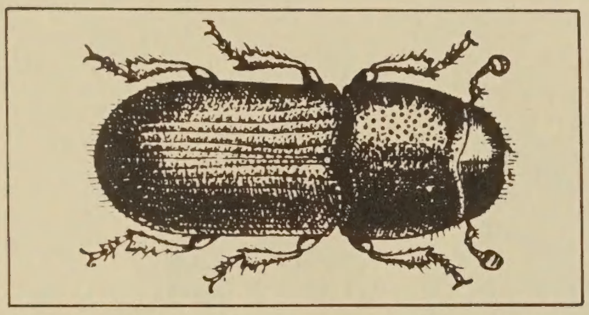
Managing Southern Forests to Reduce Southern Pine Beetle Impacts

Long- and Short-Term Strategies and Research Needs



LONG-TERM STRATEGIES AND RESEARCH NEEDS FOR MANAGING SOUTHERN FORESTS TO REDUCE SOUTHERN PINE BEETLE IMPACTS

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EXECUTIVE SUMMARY

From 1982 through 1985 the South experienced the worst recorded outbreak of the southern pine beetle (SPB). Losses exceeded 617 million board feet of timber valued at over $92 million on national forests alone. Losses to this insect have grown on national forests because stand conditions have developed to the point where they are highly susceptible to the SPB.

In response to the extreme severity of the situation, the Chief of the Forest Service appointed a core team to develop both long and short-term strategies for the control and prevention of timber losses from SPB. The specific charges to the team were:

-- Develop strategies that can be used for the current outbreak and where appropriate, incorporate them into the SPB final environmental impact statement,

-- For short term strategies, evaluate priorities for funding projects and managerial and administrative procedures. Develop an action plan to deal with the current outbreak,

-- Identify and evaluate long-term strategies to reduce SPB-caused losses. Develop an action plan for implementing these strategies,

-- Identify research and application needs whose solution would further aid resource managers in preventing and/or suppressing the SPB. Make recommendations on priority needs to Forest Insect and Disease Research and Forest Pest Management.

Research results indicate that SPB epidemics can be attributed to one or more of the following factors: 1) favorable environmental conditions such as warm weather or lack of predators, and 2) an increase in susceptibility of forest host types.

SPB prefer loblolly and shortleaf, but will attack and colonize all species of southern yellow pines, whether in pure pine stands on in mixtures with hardwoods. Hazard rating systems generally recognize that the most susceptible stands are those with greater stocking densities and with older trees.

We believe there are two important changes in forest conditions over the last three decades that have contributed to the severity of recent epidemics: 1) pine stands have become more densely stocked, and 2) pine stands have, on average, become older. These changes in forest resource characteristics mean that food and habitat for the SPB have been greatly enhanced over the years.

Data from forest surveys of the South indicate that acreage of pine and pine/hardwood type was about 100.9 million acres in 1952, and has since fallen to about 88.9 million acres in 1985. Volume lost from decreases in pine forest types has been more than offset by increased volumes on the fewer acres remaining in pine.

Stocking density (volume per acre) of pine forests in the south has significantly increased on national forest lands and has increased even more on all other ownerships since 1952. Therefore, while total pine acres have been falling, density has dramatically increased. Increased density is thought to be an important contributing factor in the current outbreak.

Little data exist concerning the average age of pine stands on all ownerships. However, sawtimber volume can be used as a proxy for age. The volume of softwood classified as sawtimber has increased dramatically since 1952. Sawtimber volume almost doubled between 1952 and 1977. Sawtimber volume has increased more than total volume. Age class distributions on national forests clearly indicate that acreages are unbalanced toward older age classes. Older stands of larger trees are thought to be another important contributing factor in the current outbreak.

The foregoing reasons, while not conclusive, may explain the cause of the recent SPB epidemic in the Midsouth. National forest and Forest Survey data indicate that pine forests in the south have become older, more densely stocked and therefore more susceptible to SPB attacks.

Preliminary projections of softwood volumes in the south through the year 2000 indicate that stand densities will continue to increase. Therefore, future outbreaks are likely to occur.

Actions are recommended that will reduce susceptibility and losses to this insect pest. These actions are designed to reduce the acreage of old and dense stands that are so vulnerable to the beetle. The actions that would have the most effect are: (1) reducing the acreage in mature and overmature timber and (2) lowering rotation ages. Other actions that will help lower susceptibility are: (1) thinning dense stands, (2) changing species, and (3) using hardwood barriers. Over time, these actions will achieve and maintain healthy, vigorous forests. However, other considerations do not permit implementing these actions to the extent desired to reduce SPB susceptibility. Thinning dense stands offers the most promise and can be implemented immediately.

Many of the recommended actions require changes in management philosophies and some may require changes in current land management plans. These changes should be considered when plans are revised or ammended. There will be some conflicts with other resources. The tradeoffs must be analyzed and decisions must be made as to which and how much of the actions to accomplish. We must remember that SPB epidemics are sporadic and will continue to occur if forest conditions are maintained that are conducive to catastrophic outbreaks. Outbreaks of the magnitude of the last 3 years cause more conflicts with other resources than a planned program of maintaining healthy, vigorous forests.

Recommendations presented here take advantage of research discoveries made over the last 20 years. However, there are very important aspects of SPB biology and dynamics where additional information is needed for more effective integrated pest management of SPB. Research needs are listed, prioritized and discussed. The research problems are difficult. Administrative and financial support are needed for long periods of time. The answers are needed to provide land managers with techniques for rapid response and long-term solutions. Research needs of particular importance include knowledge of SPB dispersal, population dynamics, microorganism relationships, growth and yield of natural older stands, effects of silvicultural treatments on older stands and new or improved control techniques.

A major demonstration project should be established that includes at least one National Forest. State-of-the-art Silvicultural preventive and control techniques would be used.

Implementing the actions included in the short-term (appendix C) and long-term documents will do more than help national forests. It will provide information and demonstrate results to landowners and land managers throughout the south.

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I. INTRODUCTION

The southern pine beetle (SPB) is the most destructive of the eastern species of bark beetles and occurs throughout the Southeastern and Southern United States. It prefers loblolly and shortleaf pines, but under epidemic conditions it will attack most pine species within its range causing a great degree of damage to timber and indirectly to other resources. The insect attacks pines in natural stands and plantations. Although records in the late 1800's and early 1900's are sketchy, it is apparent that the insect caused damage throughout the South.

As record keeping improved and control efforts intensified the magnitude of the damage became more apparent. From 1960 to 1978, in 12 southern states, it has been estimated that total volume of timber killed was nearly 9 million cords and 3 billion board feet. The loss was valued at more than $225 million. This period included the severe outbreak of 1976, which up to that point had been the worst outbreak in history.

The most recent epidemic of SPB began in the Gulf South in 1982 and got markedly worse over the next 3 years. Estimated losses during this period amounted to $92 million on national forests alone. Heavy losses in southern national forests led the Forest Service to appoint a core team to develop short-and long-term strategies and research needs to prevent and control the SPB. Their specific charge is included as Appendix B.

This document includes the core team's recommended long-term strategies and research needs to prevent and control SPB on national forests in the South. A companion document addressed short-term strategies. That document is included as Appendix C. Several short-term strategies set the stage for recommendations in this report.

Recommendations are based on the core team's examination of available research and operational data and draw from experience of the team and those providing guidance and support. The specific charges to the team for this report were:

- -- Identify and evaluate long-term strategies and tactics which will reduce SPB-caused losses. Develop an action plan for implementing these strategies and tactics on national forests,

- -- Identify research and application needs that would aid resource managers in improving their prevention and suppression strategies to reduce losses caused by SPB. Make recommendations to Forest Insect & Disease Research and Forest Pest Management.

Although the SPB had been a pest of southern forests for many decades, the Forest Service did not establish a formal research program on this insect until the 1960's. This new work was conducted principally at Pineville, LA in the Southern Station and at Research Triangle Park in the Southeastern Station. In the early 1970's work at Pineville increased and by agreement with the Washington Office, the Southern Station became the lead Station for research on the insect. However, the effort was still relatively small, involving five scientist-years.

SPB infestations spread rapidly across the South in the early 1970's and an Expanded Southern Pine Beetle Research and Applications Program was initiated by the USDA Secretary's office to study the problem. This Program operated from 1974-1980, and at its conclusion another program, broader in scope, was initiated to take advantage of new information. This program, first operated out of WO-Research and later transferred to the Southern Station, was named the Integrated Pest Management

Research Development and Applications Program for Bark Beetles of Southern Pines. It was terminated at the end of FY 85. Both these programs were large coordinated research and development efforts. Both relied heavily on the university sector and emphasized rapid dissemination of new findings. Current Forest Service and university research efforts are now approximately at the pre-1974 level.

Many of the management recommendations in this and the short-term strategies document take advantage of research and other information gained over the last 20 years. These recommendations should help improve the situation. It is clear, however, that important gaps in knowledge still remain. These gaps will have to be filled to effectively prevent and/or control future SPB outbreaks on a timely basis.

Data from the Southern and Southeastern Stations Forest Surveys of the south (Table 1) indicate that acreage of pine and pine/hardwood type was about 100.9 million acres in 1952, and has since fallen to about 88.9 million acres in 1985. Volume lost from decreases in pine forest types has been more than offset by increased volumes on the fewer acres remaining in pine.

Stocking density (volume per acre) of pine forests in the South has significantly increased on national forest lands and has increased even more on all other ownerships since 1952 (Tables 2&3). Therefore, while total pine acres have been falling, density has dramatically increased. Increased density is thought to be an important contributing factor in the current outbreak.

Little data exist concerning the average age of pine stands on all ownerships. However, sawtimber volume can be used as a proxy for age. Table 4 indicates that the volume of softwood classified as sawtimber has increased dramatically since 1952. On national forests, the sawtimber volume almost doubled between 1952 and 1977. The same is true on all ownerships during this period. Sawtimber volume has increased more than total volume. Older stands of larger trees are thought to provide very favorable conditions for the current, and probable future outbreaks.

Age class distributions on selected national forests, derived from draft or final land and resource management plans, are shown in table 5. Clearly acreages on "suitable lands"[1] is unbalanced toward older age classes. "Unsuitable lands"[2] may be even older. Acreages on Table 6 shows the age class distribution on national forests in the Southeast.

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1. Suitable Forest Land - Land that is to be managed for timber production on a regulated basis.

2. Unsuitable Forest Land (Not Suited) - Forest land that is not managed for timber production because (a) the land has been withdrawn by Congress, the Secretary, or the Chief; (b) the land is not producing or capable of producing crops of industrial wood; (c) technology is not available to prevent irreversible damage to soils, productivity, or watershed conditions; (d) there is no reasonable assurance that lands can be adequately restocked within 5 years after final harvest, based on existing technology and knowledge, as reflected in current research and experience; (e) there is at present, a lack of adequate information on responses to timber management activities; or (f) timber management is inconsistent with or not cost efficient in meeting the management requirements and multiple-use objectives specified in the Forest Plan.

   The foregoing reasons, while not conclusive, may explain the cause of the recent SPB epidemic in the Midsouth. National forest and Forest Survey data indicate that pine forests in the South have become older, more densely stocked and

therefore more susceptible to SPB attacks. Table 7 & 8 shows preliminary projections of softwood volumes in the Midsouth and Southeast through the year 2000. These projections indicate that stand densities will continue to increase. Future management strategies should profitably concentrate on thinning and shortening of rotation ages as a means of reducing SPB damage.

Table 1. Area of pine and oak/pine timberland in the South, by survey year.

YEAR	FOREST TYPE				TOTAL	
	Pine		Oak/pine			
	--(Thousands of acres)--					
	Area	% Change*	Area	% Change	Area	%Change
1952	73,833	--	27,088	--	100,921	--
1962	72,495	-1.8	27,501	+1.5	99,996	-1.0
1970	68,836	-6.8	29,185	+7.7	98,021	-2.9
1977	64,663	-12.4	28,845	+6.5	93,508	-7.3
1985	62,124	-15.9	26,807	-1.0	88,931	-11.9

* % Change from 1952.

Table 2. Average softwood volume per acre for pine and pine/hardwood forest types in the Midsouth, by survey year, by ownership class.

YEAR	OWNERSHIP CLASS			
	National Forests		All Ownerships	
	-- (Cubic feet/acre) --			
	Vol.	% Change*	Vol.	% Change
1952	687	--	441	--
1962	973	+41.6	611	+38.5
1970	1,000	+45.6	762	+72.8
1977	1,210	+76.1	922	+109.1
1985	1,271	+85.0	1,017	+130.6

*Change from 1952

Table 3. Average softwood volume per acre for pine and mixed pine-hardwood forest types in the Southeast, by survey year and ownership class.

YEAR	OWNERSHIP CLASS			
	National Forests		All Ownerships	
	- - - Cubic feet/acre - - -			
	Vol.	% Change *	Vol.	% Change
1952	870	--	580	--
1962	917	+5.4	660	+13.8
1970	1,068	+22.8	764	+31.7
1977	1,136	+30.6	885	+52.6
1985	1,151	+32.3	980	+68.9

*% Change from 1952

Table 4. Net softwood sawtimber volume in the South, by survey year, by ownership class.

YEAR	OWNERSHIP CLASS			
	National Forests		All Ownerships	
	-- (Millions of bd. ft.) --			
	Vol.	% Change *	Vol.	% Change
1952	18,590	--	96,556	--
1962	27,063	+45.6	245,712	+25.0
1970	28,924	+55.6	295,804	+50.5
1977	33,979	+82.8	341,022	+73.5

*Change from 1952.

Table 5. Age class distribution of suitable acres on the Mississippi, Kisatchie, Alabama and Ouachita National Forests.

AGE (YEARS)	AREA	PROPORTIONS	
	Thousand Acres	% of Total	Cumulative % of Total
0-9	347	14	14
10-19	221	9	23
20-29	139	6	29
30-39	143	6	35
40-49	345	14	49
50-59	311	13	62
60-69	383	16	78
70-79	466	19	97
80-89	39	2	99
90 +	9	1	100

Table 6. Age class distribution of pine and mixed pine-hardwood stands on National Forest in the Southeast (Virginia, North Carolina, South Carolina, Florida and Georgia).

AGE (YEARS)	AREA	PROPORTIONS	
	Thousand Acres	% of Total	Cumulative % of Total
0-9	264	13	13
10-19	226	11	24
20-29	109	5	29
30-39	221	10	39
40-49	435	21	60
50-59	352	17	77
60-69	241	11	88
70-79	114	5	93
80+	154	7	100

Table 7. Preliminary projections of average softwood volume per acre - pine management types in the Midsouth.

MANAGEMENT TYPE	YEAR		
	1985	1990	2000
	--(Cubic Feet/Acre)--		
Pine plantation	700	1,293	1,230
Natural pine	1,505	1,223	1,127
Mixed pine-hardwood	634	729	732

Table 8. Preliminary projections of average softwood volume per acre, by pine management types in the Southeast.

MANAGEMENT TYPE	YEAR		
	1985	1990	2000
	--(Cubic feet/acre)--		
Pine plantation	644	1,029	1,087
Natural pine	1,347	1,147	970
Mixed pine-hardwood	616	595	522

Successful management of the SPB problem requires (1) long-term silvicultural treatment of forested lands to lower stand susceptibility, (2) continuous monitoring, (3) aggressive suppression action during initial stages of an epidemic and (4) filling information voids relating to SPB. This will involve some major changes in current management policies and practices. We believe that:

-- The greatest long-term benefits can be achieved by actions that will significantly reduce acreage of mature, overmature, and dense stands.

-- Infestations should be systematically controlled while they are still small. At that time, there is a high probability of preventing or minimizing significant losses while continuing to achieve overall management goals.

-- The risk of severe damage can be reduced by regulating stand density through routine thinnings. For thinning to be highly effective, it must start early in the life of a stand. It does not appear that thinnings in stands 50 years or older will significantly improve individual tree vigor. However, wider spacing from thinning should reduce the potential for spot growth and provide benefits for red-cockaded woodpeckers and other wildlife species. Further research is needed to determine optimum densities for stands over 50 years old.

-- Information voids can be identified and addressed to aid in preventing and/or controlling future outbreaks.

-- Implementation of actions recommended in this document and those in the short-term strategies document will provide information to managers of all ownerships to prevent and control SPB infestations on an area-wide basis.

-- Information needs and technology transfer will be improved through scheduled meetings as established in the short-term strategies document, between Southern Region and Southern and Southeastern Station personnel. Such meetings are critical in identifying emerging problems and sharing existing or new technology in both epidemic and endemic periods.

The research problems identified in this document are difficult to address. Substantial administrative and financial support of qualified, interested scientists are needed over long periods of time to assure success. The dramatic losses caused by the current outbreak during the past four years (estimated at over $92 million in stumpage values on national forests alone) point to the need for aggressive research programs and silvicultural activities to reduce the potential for serious, continuing losses and incidence of future outbreaks.

Current and previous outbreaks can be tied to stand conditions. Large acreages of well-to-overstocked susceptible host types exist, as do large acreages of older age classes. <u>These conditions will continue to exist for a long time. Therefore future outbreaks of SPB are likely to occur</u>. Over time, forest conditions can be modified to reduce seriousness of outbreaks. This document and the short-term strategies document include recommendations to accomplish this goal.

Section II describes the proposed action plan for management and section III identifies research needs. Sections IV and V include some of the background information used by the core team. Section VI contains the literature cited, prospectus (the team's charge), and the short-term strategy report.

II. ACTION PLAN - (LONG-TERM STRATEGIES)

A. Determine the Cost of Control/Prevention vs. the Value of the Resource at Risk on an Area-Wide Basis.

Action - Develop a method to include economic efficiency in allocating funds for SPB prevention and control. The existing de Steiguer-Hedden system provides a framework but it will have to be modified to include thinning regimes and new data to permit analyses at the forest level. It is recognized that economic efficiency is just one criterion that will be used in the allocation process.

Who: SE. Station

When: 9/88

B. Evaluate Need for Modifying Land Management Plans to Lower the Risk of High Hazard Stands by:

1. Shortening Rotation Ages

Action - Utilize available information on SPB risk and economic costs of older stands as well as available research and historical information to modify land management plans to shorten rotation ages.

Who: Forest Supervisors

When: At midcycle of LMP or earlier revisions or ammendments

2. Decreasing Acreage of Mature and Overmature Stands.

Action - Reduce acreage of mature and overmature stands on lands classified as suitable for timber production on a regulated basis.

Who: Forest Supervisors

When: As compartments are entered and at midcycle of LMP or earlier revision or ammendment

3. Decreasing Stocking Levels.

Action - Reduce stocking to recommended levels in high-and medium-risk stands.

Who: Forest Supervisors

When: As compartments are entered

4. Regenerating With Alternative Species or Changing Species Composition.

Action - Utilize available information to modify LMP's to regenerate more acreage to less susceptable species (e.g. longleaf pine) and species mixtures.

Who: Forest Supervisors

When: At midcycle of LMP or earlier revision or ammendment

5. Increasing the Use of Hardwood Barriers

Action - Modify LMP's to regenerate more areas of hardwood barriers on suitable sites

Who: Forest Supervisors

When: At midcycle of LMP's or earlier revisions or ammendment

6. Increasing Forest Diversity

Action - Increase diversity of age-class distribution, stand sizes and species mixtures.

Who: Forest Supervisors
When: As compartments are entered

C. Improve Detection and Monitoring of SPB Infestations During Endemic Years and Improve Record Keeping Systems.

Action - An action item in the short-term strategy report called for establishing minimum record-keeping requirements for SPB infestations. These minimum requirements will be reviewed annually, and appropriate revisions will be made to improve them.

Who: So. Station
SE. Station
RO - Forest Pest Management
RO - Timber

When: Annually

D. Develop a Plan to Demonstrate the Effects of Silvicultural Treatments, Rapid Salvage or Other Treatment of All Active Infestations During Endemic Periods to Prevent or Reduce Losses from Future Epidemics.

Action - Establish a major demonstration area using state-of-the-art silvicultural preventive and control methods for SPB.

Select one or more Forests and put in place the best silvicultural management practices for prevention of SPB and other pests, if any are significant problems (examples: annosus root rot and littleleaf disease). Use aggressive detection and treatment of SPB spots that do develop. Possible candidate forests include the Oconee, Homochitto, Angelina, Sam Houston and Sabine.

Who: Regional Forester
Forest Supervisor
So. Station

When: FY 87

Addendum

This report was presented to the Chief of the Forest Service on July 1, 1986. At that time the Chief and his Staff directed that several additional items be added to the report. The items and responsible parties are given below.

1. Determine the efficacy of conversion from loblolly pine to longleaf pine to impede SPB attacks.

   SO Station
   R8 - Forest Pest Management
   Timber Management

2. Analyze the historic pattern of SW-NE trends in SPB epidemics.

   R8 - Forest Pest management
   SO Station
   SE Station

These additional items will be considered by a coordination team named by the Regional Forester, Region 8, and the Station Directors for Southern and Southeastern Stations. Special study groups may be formed to analyze or implement the items.

III. RESEARCH NEEDS

Numerous discussions have taken place between Research Stations (SO and SE), Region 8, and university cooperators. A meeting in Alexandria, LA on March 28, 1986 developed five major research needs, and priorities were assigned. This meeting was a direct outgrowth of a needed action identified in the short-term strategies document (see Appendix C, Action Item J). The action was carried out before this document was approved because the Regional Forester and Station Director for Southern Station wanted to quickly address some coordination matters and have their respective staffs come to agreement on the high priority needs in the area of spot proliferation and population dynamics. At the meeting, attended by representatives on the SPB Core Team and universities likely to cooperate in the research, the needs identified in preliminary drafts of this report and the draft SPB EIS were examined, prioritized and grouped under more comprehensive statements.

Research needs listed are in decending order of priority. Future cooperative meetings will be held to refine projects that will address these research needs.

A. Evaluate and Quantify SPB Dispersion and the Phenomenon of Spot Proliferation.

Action - Initiate work proposed by RWU SO-4501 to track beetles as they emerge from infested trees. Develop new tracking techniques to address this need.

Who: So. Station

B. Develop Techniques and Methods to Predict SPB Population Trends and the Onset, Duration, and Collapse of Epidemics.

1. Develop Methods to Identify Increases or Decreases of SPB Populations From One Year to the Next in Different Physiographic and Climatic Regions of the South.

Action Item 1 - Initiate a year-round study over a wide range of management conditions that includes aerial detection, ground observation, and evaluation of SPB brood quality and quantity to determine if there are observable factors that are consistently associated with significant changes in population trends.

Who: So. Station
Selected Forest
RO - Forest Pest Management

Action Item 2 - Funding has been approved for cooperative research with the University of Arkansas and Mississippi State University to develop highly integrated studies of SPB population dynamics, microorganism complex, and host, site and environmental conditions associated with SPB infested and uninfested stands. These studies should be completed.

Who: So. Station

Action Item 3 - Based on results from the above studies, initiate other studies to fill information gaps. Give particular emphasis to SPB population dynamics during fall, winter, and early spring.

Who: So. Station

Action Item 4 - Using information gained from population studies, develop and/or improve models to predict population increases or decreases.

Who: So. Station
RO - FPM

2. Determine the Conditions That Trigger SPB Epidemics or Cause Them to Collapse; Continue Research on the Incidence of Bluestain as it Relates to the Development or Collapse of SPB Outbreaks; Conduct Population Dynamics Studies to Determine if SPB Microorganism Complex Can be Used to Predict the Expansion or Collapse of SPB Outbreaks.

Action Item 1 - Initiate studies of SPB populations in several states to record the incidence of bluestain as an epidemic expands or collapses.

Who: So. Station

Action Item 2 - Expand studies of SPB microorganism complex to determine the role of microorganisms in the epidemiology of SPB.

Who: So. Station

Action Item 3 - Using information gained from the above studies develop predictive models.

Who: So. Station

C. Improve or Develop Long-Term Prevention and Control Techniques Giving Priority to Economically Feasible, Environmentally Acceptable Approaches.

1. Conduct Studies to Determine the Effects of and to Improve Long-Term Prevention Efforts, Particularily on Older Natural Stands.

Action Item 1 - Much of the southern pine forests will continue to be natural older stands. Such stands are the most critical consideration for SPB. Growth and yield research has emphasized plantations and younger stands. Studies are needed to collect tree and stand data to develop models to depict development of older stands.

Who: SE. Station
So. Station

Action Item 2 - Many stands will be carried past culmination of mean annual increment and planned rotation ages because of considerations other than timber management and insect and disease control. Studies are needed to determine growth and vigor responses to various thinning strategies in older stands and quantify stand dynamics and tree characteristics as related to incidence of SPB attack for these critical stand types.

Action Item 3 - Conduct research on relationships between host tree physiology and susceptibility to SPB attack and subsequent tree mortality.

Who: SE. Station
So. Station

Who: SE. Station
So. Station

2. **Improve or Develop Control Techniques Giving Priority to Economically Feasible, Environmentally Acceptable Approaches.**

Action Item 1 - Conduct research on behavioral chemicals to determine efficacy of formulations and develop deployment strategies.

Who: So. Station
SE. Station

Action Item 2 - Conduct research on biological control organisms to determine their roles and develop methods to enhance their effectiveness.

Who: So. Station
SE. Station

D. Determine the Effect of Various Silvicultural Practices on Insect and Disease Incidence in Older Stands.

Action Item 1 - Disagreement exists about the impact of annosus root rot in older stands. These disagreements need to be resolved. This report recommends thinnings to reduce susceptibility to SPB. Studies are needed to determine the impact of silvicultural treatments and severity of annosus root rot in older stands.

Who: SE. Station

Action Item 2 - Littleleaf disease and SPB are the most serious forest pests affecting conifers (loblolly and shortleaf pine) in the Piedmont. Interactions among site quality, fungus, host trees and SPB need to be studied. Emphasis should be placed on tree and stand stress physiology in relation to pest incidence and severity.

Who: SE. Station

E. Determine if There is Genetic Resistance in Pines to SPB Attack.

This item was identified in the prospectus. Although there are some indications that genetic variation in resistance exists, the team believes that discovery and application of such resistance requires high-risk, long-term research. Therefore we have assigned it a low priority for research. This decision is based on the time factor and the investment required, the low probability of developing an adequate supply of resistant planting stock and the low probability of south-wide use. Another consideration is the possibility that SPB populations will adapt to attack resistant strains.

IV. BACKGROUND - LONG-TERM STRATEGIES

A. Determine the Cost of Control/Prevention vs. the Value of the Resource at Risk on an Area-Wide Basis.

Each year, the Forest Service receives funds to control SPB outbreaks on the national forests. Some of these funds must be immediately set aside to deal with outbreaks that will affect environmentally sensitive areas such as red-cockaded woodpecker habitat. However, beyond those legislatively required allocations, no method exists for the economically efficient allocation of funds to protect commercial timber resources. A method is needed for allocating funds among the national forests that is based on the costs of SPB control, current and projected lewels of SPB activity and the value of the resource at risk.

The method should be based upon economic efficiency criteria. Once developed, it can be incorporated into routine Forest Service planning to assure the efficient allocation of SPB funds to national forests. The same methodology can be used to allocate SPB control funding to the respective states. It is recognized that economic efficiency is only one of several criteria which will be used to allocate funds.

Objectives

The objectives of this effort are:

1. To determine the appropriate economic efficiency criteria and capital budgeting procedures for allocating limited funds among competing SPB control projects.

2. To develop the necessary biological models and gather the data needed to conduct a regional economic efficiency analysis for SPB control.

3. To conduct economic analyses of each of the national forests in the South to determine: a) the optimal level of SPB control expenditure, and b) those national forests which should receive the highest priority in SPB control funding.

Procedures

The problem is to allocate limited SPB control funds among the separate national forests and states.

This sort of capital budgeting problem is discussed in financial management texts (Weston and Brigham 1979; Canada and White 1980; Brealey and Myers 1981). The solution, according to the last-cited authors, is as follows: "When funds are limited, we need to concentrate on getting the biggest bang for our buck. In other words, we must pick the projects that offer the highest ratio of present value to initial outlay. This is simply the benefit/cost ratio."

Certainly, in dealing with SPB, considerable difficulty is experienced in attempting to actually measure the costs of prevention and control and, especially, the resultant benefits (that is, the value of timber saved). But, at least conceptually, the solution is rather straight-forward. Expected benefits and costs of SPB prevention and control are calculated for each national forest, and funds allocated first to those with the largest expected benefit/cost ratios. Federal funds are not distributed to states for prevention. Therefore, allocation for states are confined to control funding.

Much of the early development of a modeling system to conduct the economic analysis has already been completed by de Steiguer and Hedden (1985). These authors developed a system of models which determine the optimal level of SPB control expenditure for each state, southwide, by landownership class. The system accomplishes this economic analysis as follows. Data on current stand condition from Forest Inventory and Analysis (FIA) are entered into the CLEMBEETLE simulation model. CLEMBEETLE then simulates the volume of timber that would be lost if no control and various levels of control were undertaken. Next, the Beetle Economic Analysis Model (BEAM) calculates the value of timber lost without control minus the value of timber lost with control. The difference is simply the value of timber saved due to control. BEAM also computes the costs of control and deducts these costs from the benefits of control. The difference between total benefits and costs is the net benefits of control. The optimal level of control is that which maximizes net benefits.

The de Steiguer-Hedden system provides a framework for a regional economic analysis of SPB control, but it would need to be modified in two ways. First, the system would require the inclusion of thinning models in order to analyze the effects of SPB prevention. Second, new data would need to be gathered so that the system would be capable of analyzing individual national forests. These new data would include factors such as current stand/site descriptions (e.g., age, volume, trees per acre), stumpage prices, salvage rates, cost of control activities, and so forth. The thinning models may be available from forestry literature, whereas the new data would be obtained from the separate National Forests.

Schedule of Work

Completion of this project would require 2 years. The estimated times to accomplish each objective are:

Objective #1 - 3 months

Objective #2 - 9 months

Objective #3 - 6 months

Write final report, obtain reviews and revise report - 6 months

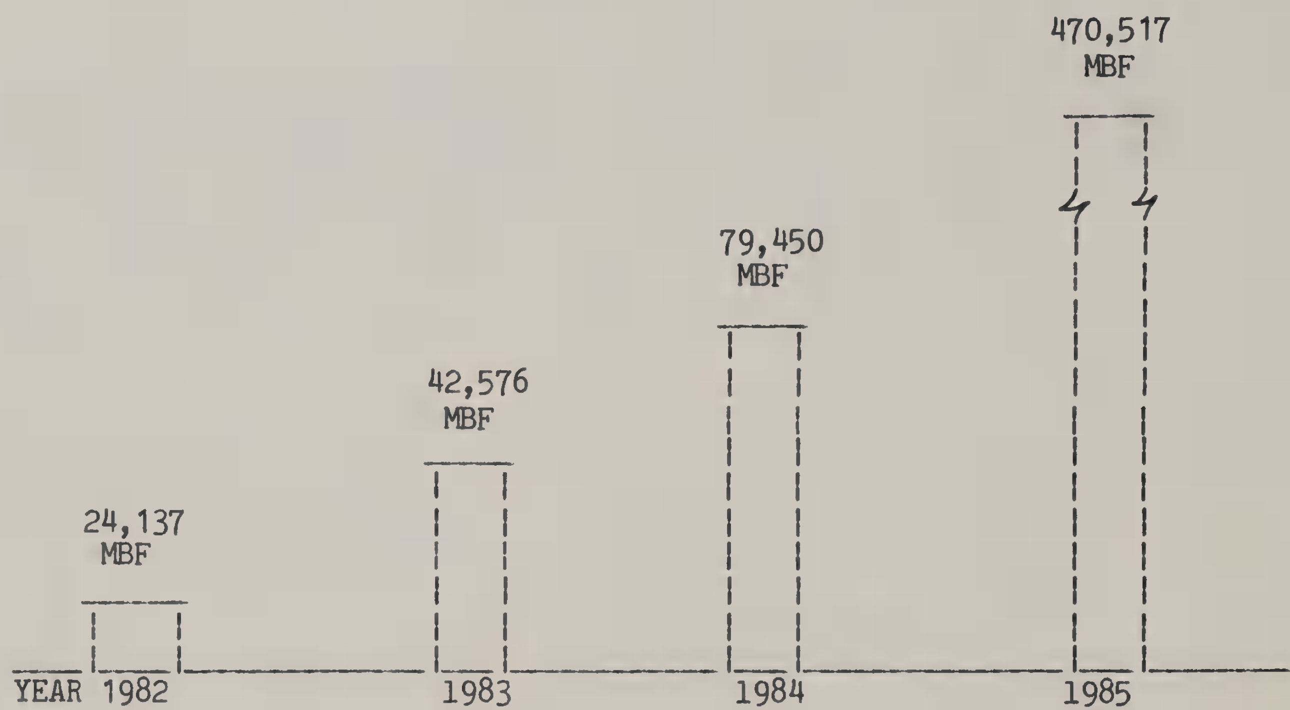
B. Evaluate Need for Modifying of Land Management Plans to Lower the Risk of High Hazard Stands by Lowering the Susceptibility of High Hazard Stands to SPB Attack and Spot Spread.

Losses caused by the SPB on national forests have increased dramatically since 1981 (figure 1). Losses on national forests in the South are estimated 616,680 MBF in the last 4 years alone. Computed at an average stumpage price of $150 per MBF this loss amounts to a staggering $92,502,000. Detection and evaluation surveys indicate that beetle outbreaks will continue to be widespread and serious across the South in 1986. Correlation between losses from SPB infestations and forest composition and structure (stand age, density, tree size, and distribution) clearly show the probability and potential for beetle losses on national forests could remain high for the forseeable future. Preventive long-term silvicultural and management strategies could reverse these disruptive and costly trends.

Implementing the recommended strategies could have tremendous positive economic effects. A present net value analysis using current prices and costs shows the highest PNV for loblolly pine on SI 80 is $854 per acre at ages 45 & 50. If the same stand is grown to age 75 and infested by SPB and sold at salvage prices, the PNV is a minus $140. This makes a total difference of $994 per acre.

Present income loss attributed to SPB is even more spectacular. Many acres lost in the present epidemic had 12 MBF or more per acre. Much volume was sold for as low as $10 per MBF versus green prices in years without SPB outbreaks of $160 or more. A large volume could not be sold due to market conditions. The per-acre loss, where salvage was possible, was $1800 (12 MBF X $150). Clearly, lowering stand risk to SPB attack has a potentially high payoff!

Figure 1.--Southern pine beetle losses on National Forest.
Source: Southern Forest Insect Work Conference loss assessment report; 1982-1985.



The first step in a preventive approach involves the recognition of conditions favoring infestation incidence and spot growth. Several methods are available to rate the relative susceptibility of stands to SPB attack (Mason et al. 1985). SPB hazard rating has been initiated or scheduled for most national forests in the South (see companion document on short-term strategies).

SPB hazard ratings provide useful information to prioritize need, scheduling, and timing of appropriate treatments. The potential for SPB spot initiation, growth, and volume loss is greatest in high-risk stands. These stands should receive earliest management attention. The probability of occurrence and potential for losses are less in moderate- and low-risk stands. It is important that silvicultural practices maintain vigorous conditions in these stands.

The following cultural practices are recommended to produce environmental and biological conditions unfavorable for attack, spread and population growth of SPB:

* Shortening rotation age
* Decreasing acreage of mature and overmature stands
* Decreasing stand density

* Favoring most resistant species or changing species composition
* Increasing the use of barriers
* Increasing forest diversity

The efficacy of these measures will vary with conditions and multiple management objectives of national forests across the South.

a. Shortening rotation age.

One of the principal objectives of the Expanded Southern Pine Beetle Research and Application Program (ESPBRAP) was to identify site, stand, and host conditions associated with SPB infestations. Seven different projects, conducted by six organizations and covering seven states, collected a common set of site and stand data at each measurement plot.

Forest resource characteristics on the Kisatchie National Forest have been reported. Trees in infested stands averaged 44 years of age, 12.2 inches in d.b.h., and 67 feet in height (Lorio and Sommers 1981). Similar characteristics exist on the other national forests. Trees in national forests were generally larger than those on adjoining ownerships. But even within national forests, beetles apparently selected older and larger trees. It is important to note that large trees generally provide the most suitable conditions for large increases in SPB populations.

About 64 percent of the Kisatchie National Forest was in stands 35 years old and over; 83 percent of the infestations occurred in these age classes (Lorio and Sommers, 1981). Distribution of infestations across 10-year age classes for pine management types confirmed that trees in age class $\geq$ 35 were most often infested. For loblolly pine managmement types, disproportionately more infestations occurred in age classes 35 years and older with a dramatic increase in infestations beginning at age class 35.

Four hundred and seventy-seven spots and 4,956 attacked trees were measured on the Trinity District of the Davy Crockett National Forest between July 1974 and June 1975 (Leuschner et al. 1976). Trees attacked by the SPB had larger than average diameters and occurred in dense pure pine stands. Susceptibility appeared to be related to age rather than site, since most of the infestations occurred on fairly moist sandy loam soils which usually support healthy pine stands.

It is difficult and biologically inappropriate to isolate age from other factors contributing to SPB attack. Site index and stand density need to be considered as well. In Arkansas, young, small-diameter trees were infested more frequently than older, larger trees (Ku et al. 1977). These beetle-attacked stands contained a greater number of pine stems and occurred on poorer sites than control plots (Ku et al. 1976).

Stand and soil conditions are related to SPB infestations on the Piedmont. Results show that highly susceptible pine stands on the Upper Piedmont of Georgia have a large percentage of shortleaf pine, slow radial growth during the last 10 years, and a high clay content in the surface and subsurface horizons (Belanger et al. 1980). Most of these stands are located on high-hazard littleleaf sites (Campbell et al. 1954). Losses from the littleleaf-SPB complex increase as stand age increases (Belanger et al. 1985)

Hedden (1983) used computer simulation to evaluate the effects of different rotation lengths on SPB caused losses in both thinned and unthinned stands. In all cases, shortening the rotation reduced losses from SPB attack. In a short rotation the stand is subjected to potential infestations for fewer years, and younger stands are generally more vigorous (greater radial growth and larger crowns relative to height)

than older stands. Young stands also tend to be less dense than older stands. All of these factors result in young stands suffering less SPB damage than older stands.

Summary - Most national forests in the South contain a disproportionate amount of contiguous, large, mature and overmature sawtimber. The SPB will continue to be a serious threat to this valuable resource as long as these conditions exist. Rotation ages of 40 to 50 years are recommended to reduce the problem. The core team recognizes that other considerations may not permit implementing the recommended rotations to the extent desired to reduce SPB susceptibility.

b. Decreasing acreage of mature and overmature stands.

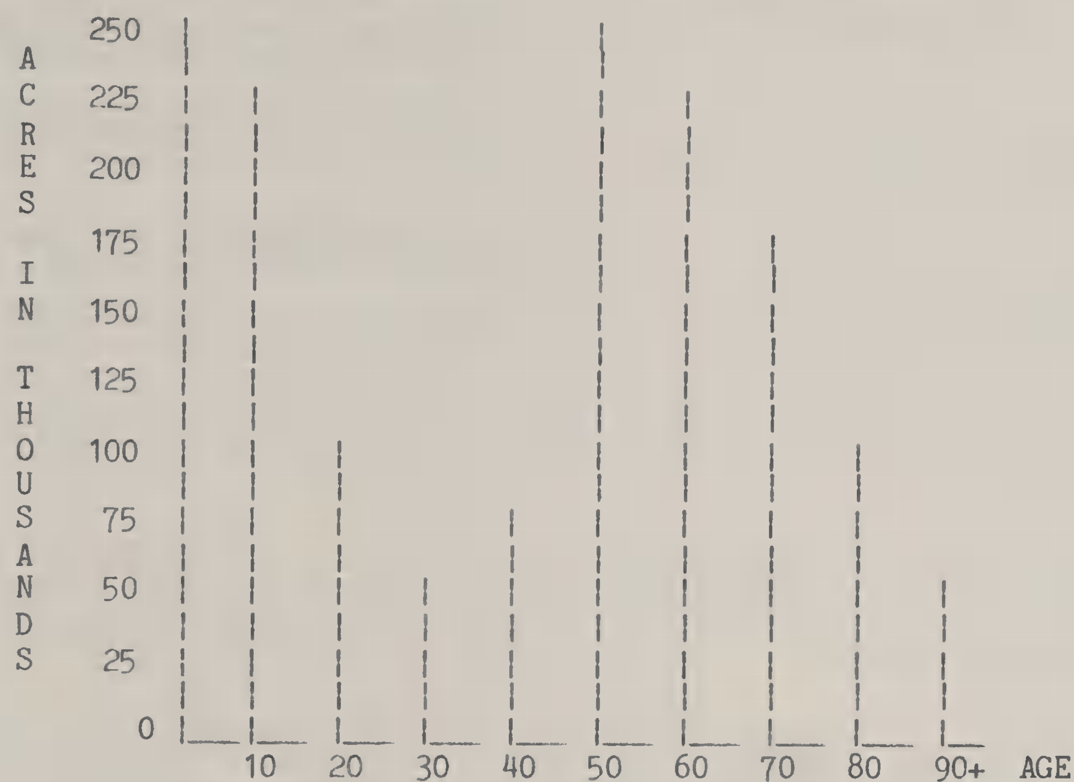
Recognizing that shortening rotations to the extent desired to reduce susceptibility to SPB may not be attainable, significant reductions of acreage in mature and overmature stands of susceptible pines should be considered to reduce SPB losses.

Stands on national forests on the Gulf Coastal Plain have often been described as "beetle-bait." The reference is to higher proportions of old and dense stands of susceptible pines. There are many reasons why these stands have developed and why decisionmakers have chosen not to reduce acreages of mature and overmature pine significantly. However, to the extent that these conditions are allowed to continue, SPB losses can be expected. The tremendous economic losses must be considered in any trade-off analysis.

The National Forests in Texas have a higher proportion of old stands than other Gulf Coastal Plain forests. Seventy-five percent of suitable (available for timber production) yellow pine stands are greater than 40 years old, 65% are over 50 years old, and 43% are over 60 years old. (Table IV-2 Proposed LMP NFs in Texas).

National Forests in Mississippi have similar age distributions; 70% > 40 years, 60% > 50 years and 38% > 60 years (P. 4-160, Proposed LMP, NFs in Mississippi). Distributions for the Kisatchie are 47, 21, and 12% (PB-17, LMP Kisatchie National Forest). Adding the acreages of all three forests shows how unbalanced suitable acres are toward the older age classes (Figure 2). Note this is only for suitable acres. Unsuitable acres may have even greater proportions of old stands.

Figure 2. Age class distribution (suitable acres) of National Forests in Texas, Mississippi and the Kisatchie NF.



Decreasing the acreage of nature and overmature stands must be considered separately from reducing rotation age. Simply reducing rotation ages without also doing something to reduce amount of mature and overmature stands will not solve the problem for decades. Current forest plans propose to carry some pine stands for 100-180 years. In such cases, the high SPB hazard associated with these old stands must be explicitly recognized.

Summary - A disproportionate acreage of loblolly and shortleaf pine on SPB susceptible forests is mature or overmature. To significantly reduce losses to SPB, many of these stands must be harvested and regenerated.

c. Decreasing stand density.

Throughout the South, the SPB severely impacts well to densely stocked, slow-growing, pure pine stands (Coster and Searcy 1981). There are now more of these types of stands than ever before (Hedden 1978, Knight and McClure 1979; Murphy 1976). Intermediate cuttings promote and maintain desirable crown size/tree height ratios as well as rapid growth of trees in young stands. Thus, they reduce losses from the SPB in these and older stands. Rapidly growing trees inhibit buildup of SPB populations within spots, even if one or a few trees are attacked (Hedden 1983). However, work by Lorio and Hodges (1971) indicates that rapid growth alone is not a reliable indicator of resistance to SPB attack. Thinning also increases distances between trees, reducing potential for infestation spread following initial attack (Gara and Coster 1968; Johnson and Coster 1978). Thinning natural stands in North Carolina (Maki et al. 1978 unpublished) reduced average spot size from almost 6 acres per infestation to less than 3 acres and appeared to reduce incidence of attack.

When to thin - Thinning is currently being planned or initiated in many mature and overmature stands Unfortunately, no field studies have been designed to evaluate thinning for preventing or reducing losses from SPB attack in older stands. It is unlikely that dense stands of mature or overmature trees will respond greatly to a decrease in stand density. The primary benefits from thinning older stands are recovery of timber at market value that otherwise is likely to be lost to SPB and increasing distances between trees which reduces potential for expansion of local infestations. Thinning mature sawtimber removes the type of host material best suited for sudden and large increases in beetle populations. Thinning can also be used to maintain growth of mature dominant and codominant trees in stands previously thinned.

Thinning is most effective in young stands. Cutting should be scheduled at the onset of competition, which normally occurs shortly after crown closure (age 15-20). Additional thinning should be scheduled as needed to maintain rapid diameter growth and satisfactory crown/height ratios.

Precommercial thinning will benefit stands overstocked at the time of establishment. The primary purpose of precommerical thinning is to avoid stress and poor growth early in the life of the stand.

Thinning will reduce but not eliminate losses to SPB. Most of these losses will probably be concentrated near the end of the rotation, when the probability of and susceptibility to SPB attack are greatest. The longer the rotation, the greater the volume and value of expected tree losses (Hedden 1983).

What to thin - Trees that are highly susceptible to SPB attack should be cut first. These include suppressed, intermediate, damaged, or weakened trees. Dominant and codominant trees should then be cut to obtain the desired density or spacing. Trees with large crown/height ratios and desirable phenotypic traits should be favored as crop trees. They will respond to thinning with increased growth after release and have the most potential for high-value products.

How much to thin - Intensity of thinning will depend upon the age of the stand, the site index and the total stand density. Residual basal areas of 80 to 100 feet^2/acre are normally recommended to reduce the potential for SPB attack in young stands (Belanger and Malac 1980). This density is in general compliance with leave basal areas listed for yellow pines except for higher site indexes in the Southern Region Compartment Prescription Field Book (USDA Forest Service n.d.). Some forests have an SPB hazard rating supplement which recommends thinning heavier than the regional guide on higher sites. Nebeker and Hodges (1985) reported that the probability of spot spread was extremely low in pine stands where basal areas were reduced to 70 feet^2/acre. The risk of beetle attack and spot spread in most instances will increase considerably at basal areas greater than 100 feet^2/acre (Coster and Searcy 1981).

Tree spacing should be an important consideration when developing thinning guidelines (Lorio 1980). Close spacing favors development of infestations; wide spacing limits spot spread. In a study of natural stands of loblolly pine, Gara and Coster (1968) found that 18 feet was the maximum distance over which infestations were able to spread from one tree to another. They concluded that expansion of a local infestation was unlikely where average tree spacing was 20 to 25 feet. Johnson and Coster (1978) reported that close spacing enhanced subsequent attacks when the rate of newly attacked trees per day was low. Distance was less critical in the presence of multiple attractant sources and a high rate of newly attacked trees per day.

Residual densities and spacings should be based on site and age of the stand. Amount and frequency of thinning are most critical on good sites. First thinnings that are too light will create a need for second and possibly third thinnings to compensate for

rapid growth on highly productive soils. Thinning guides such as those developed by Morriss (1958) based on Chapman (1942) and Miscellaneous Publication 50 (USDA 1976) can be used. The objective is to avoid excessive competition among trees for water and nutrients, and also to reduce the potential for initial SPB infestations and subsequent spot growth. Heavy thinning should be avoided in areas subject to severe wind and ice storms (Belanger and Brender 1968).

Other considerations - It is essential that any effort to manage one pest species be evaluated in terms of negative effects it may have on another pest. For example, thinning on high-hazard annosus root rot sites (> 70 percent sand in surface soil) can lead to spread of the disease and severe infection followed by a reduction in tree vigor and attack by the SPB (Skelly, Powers, and Morris 1974). Precautions should be taken to reduce the danger of annosus infection, especially on high hazard sites. Treating stumps with borax or Peniophora spores minimizes spread. Prescribed burning before and after thinning also reduces severity of annosus root rot in the South (Froelich, Hodges, and Sackett 1978). Hazard rating for annosus root rot needs to be applied in many areas of the South in order to concentrate control activities where economic benefits will be the greatest.

Summary - Intermediate cuttings are recommended to reduce losses from the SPB. Thinning older stands reduces the potential for expansion of local infestations and removes host material best suited for sudden and large increases in beetle populations. Younger stands are thinned to promote rapid growth and stand vigor.

d. Favoring most resistant species or changing species composition.

Intermediate cuttings and regeneration systems should restrict the compositition of the stand to species that are best suited to the site and most resistant to SPB attack. Slash, longleaf, Virginia, and eastern white pine tend to be more resistant to SPB attack than loblolly, shortleaf, or pitch pine (Coyne and Lott 1976; Hodges et al. 1977, 1979; Belanger et al. 1979, 1981; Ku et al. 1980). The relative susceptibility of host types can differ among geographic regions (Table 9). Differences in susceptibility are related to the physical properties and toxicity of oleoresin components (Coyne and Lott 1976, Hodges et al. 1977). The oleoresins of highly resistant pines are extremely viscous, crystallize slowly, and continue flowing for long periods of time after wounding. Southern pines with a high limonene content may be more resistant to continued beetle attack than trees with a low limonene content.

Strains of southern pines highly resistant to SPB infestation are not available for planting. The selection, testing, and propagation of resistant families will be difficult. Such a program will require administrative and financial support of qualified, interested scientists over long periods of time. (See Research Needs E).

Table 9.--The susceptibility of pine species to SPB attack in the major geographic regions of the South

	Geographic region		
Susceptibility	Coastal Plain	Piedmont	Southern Appalachians
Most resistant	Slash	Virginia	Virginia
	Longleaf	Loblolly	Eastern white
Most susceptible	Shortleaf	Shortleaf	Shortleaf
	Loblolly		Pitch

A mixture of pines and hardwoods also promotes resistance to attack and deters the spread of endemic beetle populations (Belanger et al. 1979, 1981). The SPB prefers susceptible stands that are uniform and continuous. Spread of infestations is greatest in dense pine stands (Gara and Coster 1968, Hedden and Billings 1979). Hardwoods limit infestation spread by disrupting continuity between host trees.

Pine-hardwood mixtures provide little resistance to epidemic populations of SPB. Recent observations in Texas, Louisiana, and Georgia indicate bark beetles can attack and kill pines widely distributed throughout such mixtures. Several reasons may account for this: (1) areas of pine-hardwood mixtures are usually small and can be easily overwhelmed by large numbers of beetles originating from adjacent pine stands, (2) competition with hardwoods for moisture and nutrients may cause severe stress on pines, (3) pines on these sites are often large and can support a rapid buildup of SPB populations.

Summary - Species should be favored that are best suited to the site and most resistant to SPB attack. A mixture of pines and hardwood promotes resistance to attack and spread of endemic SPB populations. Such mixtures promote little resistance to epidemic beetle populations.

e. Increasing the use of barriers

Strips of hardwoods, roads, rights-of-way and wildlife openings have been recommended for reducing the spread of SPB spots (Karpinski et al. 1984). These practices are designed to increase distances and disrupt continuity of host types. Barrier strips should be at least as wide as the average tree height in the stand. Barriers up to 100 feet wide are recommended for high-risk or high-value stands. Barrier strips should prevent or reduce the potential for spot spread when beetle populations are endemic. They are less effective during epidemics.

It must be noted that hardwoods are not suited for all sites. In some areas of the Piedmont and Coastal Plain, existing soil conditions (e.g., degradation of site from past agricultural practices) may hamper or prohibit the immediate shifting to alternative species.

f. Increasing forest diversity.

SPB outbreaks and spot growth are greatest in mature, densely stocked, pure pine stands. On many national forests, these stand conditions exist over extensive areas. Increasing forest diversity will lessen the potential impact of the SPB as well as other pests (Dinus 1974). Natural or artificial regeneration should be planned to increase the distribution of resistant species and age classes throughout the forest.

A mosaic of age classes or age distribution, small stand sizes, and species mixtures will lower the susceptibility of stands and forests to SPB attack and spot spread.

None of the recommended preventive strategies will eliminate the SPB. Reducing the susceptibility of high hazard stands, however, is the critical first step in keeping bark beetle populations at manageable levels. Reducing the potential impact of the SPB will increase the productivity of national forests across the South.

C. Improve the Detection and Monitoring of SPB Infestations During Endemic Years and Improve Record Keeping Systems.

Since 1978, a computerized record keeping system, the Southern Pine Beetle Information System (SPBIS), has been used to document SPB losses for national forest ranger districts with funded SPB suppression projects.

From 1979-1982 this information was entered on the USDA Forest Service computer at Fort Collins, Colorado. Since districts did not have direct access to this facility, the data were used predominantly for historical information and post-suppression evaluations. In 1983 a demonstration project funded by the IPM program was conducted on the Holly Springs National Forest in Mississippi. SPB data collected during suppression projects were modified, and the program was revised to run on an Apple computer. Since 1983, districts with SPB suppression projects have been provided an Apple computer. Districts have been able to enter and have immediate access to the data. Programs have been written to provide accomplishment summaries and prioritize spots for control. While this system has greatly enhanced SPB control efforts on these districts, there are no data requirements for districts that do not have SPB suppression projects.

Continuous monitoring of SPB activity in high hazard stands on ranger districts could provide an early indication of changes in levels of SPB activity. This would enable districts to respond in a timely manner to population increases or decreases.

The following action item was included in the short-term strategies document.

"Regional Forester issue a FSM supplement establishing minimum SPB spot record keeping requirements that cover both endemic and epidemic periods."

These minimum record keeping requirements need to be reviewed periodically and appropriate revisions made for their improvement.

D. Develop a Plan to Demonstrate the Effects of Rapid Salvage Removal or Other Treatment of All Active Infestations During Endemic Periods to Prevent or Reduce Losses From Epidemics.

Most SPB control efforts are concentrated during the summer when infestations are easily detected from the air. Rapid expansion of individual infestations, causing large timber losses also occurs during summer. Control efforts are aimed at stopping the expansion of individual infestations. Control efforts are apparently successful most of the time in interrupting spot growth. However, their effectiveness at preventing or changing the course of an epidemic has not been evaluated because it is difficult to determine the relationship between existing treated or untreated infestations and subsequent new infestations on an areawide basis, particularily under epidemic conditions. Most of the research on the SPB has been done during late spring through early fall period. There is a serious gap in our knowledge about this insect during late fall, winter, and early spring. Understanding the beetle's attack, brood development, survival and dispersal behavior during these times of the year is critical to understanding the epidemiology of this pest. Collateral research is needed to develop techniques to track dispersal of SPB to aid in determining seasonal dispersal behavior.

Current theories of SPB behavior indicate that most new infestations are initiated during fall, winter, and early spring. During the fall, growth of infestations decreases as beetles seem to disperse to initiate scattered new infestatons. Beetles spend the winter in all stages of development and fly at all times when temperatures are warm enough to permit such activity (Moser and Dell 1979, 1980). Beetles are larger (and presumably more vigorous) and brood survival is higher during the fall and winter than during the summer. Major dispersal is also thought to occur during the early spring, particularily in the Gulf States. New infestations initiated during the fall, winter, and early spring usually are not detected for many weeks due to slow crown discoloration.

Because spot proliferation appears to occur primarily during fall, winter, and early spring, knowledge of beetle activity at these times of the year is of great importance in understanding beetle epidemiology. Forests probably contain many infested trees during the fall, winter, and early spring that serve as beetle reservoirs. Such trees become the source of beetles for new or expanding infestations in late spring and summmer. Knowledge of the abundance and distribution of infested trees could provide the necessary data to predict the severity of SPB problems later in the year. Furthermore, control of infestations during the cooler months could reduce timber losses later in the summer and possibly influence the course of an epidemic.

Research has provided many answers for SPB prevention. A demonstration area combining the latest silvicultural treatments known to lessen stand susceptibility to SPB, and aggressive detection and treatment of SPB spots that do develop, would clearly show the value of the recommended long-term and short-term strategies.

Therefore, we propose that a demonstration project be undertaken that includes intensive surveillance of SPB activity with emphasis during fall, winter, and early spring. Aerial photography as well as intensive ground inspections would be used. The purpose would be to detect all SPB 'reservoir' trees following beetle dispersal flights but before rapid spot initiation or expansion occurs in early summer. Concurrent with

detection efforts, beetle population characteristics (such as brood production, beetle size, incidence of bluestain, etc.) would be determined to evaluate the quality of overwintering beetle populations.

If other pest organisms are significant problems on the chosen area(s), the best management practices for their prevention and control should also be implemented. Possible problems are annosus root rot and littleleaf disease.

Funding and targets would have to be increased to make the thinnings and regeneration cuts; however, these harvests would return more money to the U. S. Treasury and States than the necessary appropriations. Funding for detection and some control treatments would have to be increased.

Forests that are good candidates include the Homochitto, Oconee, Angelina, Sam Houston and Sabine. Nondeclining yield constraints may have to be relaxed to make any appreciable changes in the current predominance of older age classes.

We believe that such a demonstration would lead to similar treatments on an area-wide basis.

Some of the questions to be addressed include:

-- Can the results of an intensive presummer SPB monitoring program be used to predict losses for that year?

-- Does intensive control of populations in 'reservoir' trees during late fall through early spring influence the number of subsequent infestations in the demonstration area?

-- Should a monitoring program during winter or early spring be used on an area-wide basis?

-- Should these total treatments be applied on an area-wide basis?

V. RESEARCH NEEDS BACKGROUND

This section of the report describes research needs. It must be recognized that a number of identified research needs overlap and that results from research on one problem may apply to one or more other problems. In fact, there are a number of subproblems associated with each of the identified needs that will require further definition and design of specific studies for their solution.

A. Evaluate and Quantify SPB Dispersion and the Phenomenon of Spot Proliferation.

Research on this problem must be supported by more fundamental work on the dispersion of beetles from existing infestations. Spot proliferation may or may not be affected by control tactics employed on existing infestations. Effective research on this problem requires development of techniques for tracking beetles as they emerge from infested trees. RWU SO-4501 has begun preliminary work on this problem.

This is a high priority research item. Solving this problem will strongly contribute to understanding the epidemology of the SPB and will provide a basis for determining treatment efficacy. The knowledge gained will explain SPB behavior through seasons of the year. The best information available indicates that beetles behave much differently in the mid to late summer than in the fall, winter, and spring. Likewise, the host trees vary considerably in their physiology throughout the year and accordingly are more or less susceptible to attack depending on environmental conditions. It will be necessary to design studies that will take these phenomena into consideration.

Information gained during the fall through early spring will also contribute strongly to understanding SPB biology, ecology, and population dynamics. It is essential that studies be developed and conducted during these periods of the year as well as in the summer.

B. Develop Techniques and Methods to Predict SPB Population Trends and the Onset, Duration, and Collapse of Epidemics.

1. Determine the Conditions that Trigger SPB Epidemics or Cause Them to Collapse. Develop Methods to Identify Increases or Decreases in SPB Populations From One Year to the Next in Different Physiographic and Climatic Regions of the South.

These items were identified in the prospectus. They were combined for planning purposes. Although this area of research is definitely needed, it is very broad. It must be broken down into a number of narrower problem statements. Research on these narrower problems would have considerable bearing on the ultimate answer to this question. More basic biological knowledge is needed on the beetle itself, its associated microorganisms, insects, nematodes, and mites, and host physiological conditions thought to affect SPB success in attack and development of abundant and vigorous brood (Lorio and Hodges 1985; Lorio 1986).

Many factors may contribute to the onset of epidemics. However, a basic requirement is a large contiguous area of maturing, mature and overmature forests of suitable host type. Hedden (1978) pointed out that commercial forest land in Texas has declined 6% since 1955 while growing stock volume per acre has almost doubled, and SPB populations have increased almost tenfold. Louisiana's softwood sawtimber growing stock volume has more than doubled since 1955 (based on information from the most recent forest survey). Prior to the early 1960's the SPB was virtually unknown in Louisiana. Since that time, infestations have become common, with epidemics developing sporadically. Safranyik and others (1974) showed that mountain pine beetle infestations in lodgepole

pine tend to occur more often as the current annual increment declines and that they intensify after culmination of mean annual increment. A similar relationship seems to exist between the SPB and loblolly pine. SPB problems become evident around age 30 and intensify with age, at least through culmination of board-foot mean annual increment (Lorio 1978). Culmination of board-foot mean annual increment for loblolly pine occurs at about 40 to 45 years of age for loblolly pine (Davis 1966). Forest survey data offer a good basis for quantifying significant forest resource changes since the 1930's.

It will be essential to include observations of SPB activity through fall, winter, and spring (periods generally ignored in past research on population dynamics, with few exceptions). Merely determining number of infestations detected by aerial detection flights at intervals during that part of the year is not likely to provide the needed information. Aerial detection, ground observation, and evaluation of brood quality and quantity over large areas involving a variety of management situations will likely be needed to determine if there are any factors that consistently signal significant changes in overall population characteristics.

2. Continue Research on the Incidence of Bluestain as it Relates to the Development or Collapse of SPB Outbreaks. Conduct Population Dynamics Studies to Determine if SPB Microorganism Complex Can be Used to Predict the Expansion or Collapse of SPB Outbreaks.

These items were identified in the prospectus. They were combined for planning purposes, because both concern the relationship of microorganisms to SPB outbreaks. Work has been initiated on aspects of both items.

Recent research has shown a relationship between SPB population levels and bluestain. During the initial stages of the epidemic in Texas in 1983, some SPB infestations were found to have no bluestain (Bridges et al. 1985). In 1984, levels of bluestain were less on the Sam Houston National Forest, one of the areas hardest hit by the outbreak, than in Louisiana and some other parts of Texas (Bridges 1985). Bluestain levels also decreased in Louisiana during 1985 as the outbreak intensified in that State. Field observations made during the outbreak in Texas in the mid 1970's indicated that more bluestain was present in infested trees during the collapse of the epidemic than was found during the height of the epidemic (Texas Forest Service. 1978).

Funding has been approved for cooperative research with the University of Arkansas and Mississippi State University to develop highly integrated studies of SPB population dynamics, the microorganism complex, and host, site, and environmental conditions. Results from this research will contribute significantly in improving existing population dynamics models and provide a basis for refining predictive models in the future.

There is a significant need for knowledge of basic relationships between host stand characteristics and SPB population dynamics. Work aimed at refining SPB population dynamics models must involve closely integrated studies of beetle population dynamics and tree, stand, and site characteristics. Studies of associated insects and microorganisms should be included to provide information on their quantitative effects on SPB populations. Mites in particular are important to understanding the microorganism-host complex. Bridges and Moser (1983) found that certain *Tarsonemus* mites that ride emerging SPB are responsible for vectoring bluestain. Moser (1985) showed that *Ceratocystis minor* ascospores are carried by the mites in certain mycangia-like structures. In the absence of mites, the fungus may not be transmitted from one tree to another. In such studies trees must be considered. In pines, this balance governs normal physiological changes that affect both resistance and

suitability for brood development, as well as susceptibility to fungus infection and suitability for fungus growth and development (Lorio and Hodges 1985, Lorio 1986).

C. Continue to Improve or Develop Long-Term Prevention and Control Techniques Giving Priority to Economically Feasible, Environmentally Acceptable Approaches.

The information contained in this document clearly indicated that stand conditions conducive to SPB outbreaks will continue to exist for the forseeable future (see sections I & IV). Research is needed, particularly in older stands, to determine vigor responses to silvicultural treatments and to develop growth and yield information.

Much of the southern pine forests is and will continue to be naturally regenerated and essentially even-aged. Dense, older stands are the most critical consideration for SPB and there is a lack of data and models to depict their development. Growth and yield research has emphasized plantations and generally younger stands. A concerted effort is needed to collect tree and stand data in the critical catagory.

Additional formulations are needed to express tree and stand variables that control the SPB defense process. It is possible that an individual tree type growth and yield model could be adapted to express these additional variables and linked with components that depict stress conditions.

Various silvicultural strategies are considered to be the most viable indirect control measure of SPB. Improved growth and yield models and information regarding vigor responses are needed. This information will also be useful in future revisions or ammendments of forest land and resource management plans.

Through examination of the literature and discussions with experienced researchers and Forest Service personnel, it was affirmed that four methods are currently available for control of SPB outbreaks: 1) cut and remove, 2) cut and leave, 3) cut, pile and burn, and 4) cut and spray with insecticides. Of these four methods, the preferred technique is cut and remove. However, where salvage markets are weak, the cut and leave method is also recommended. The use of insecticides and burning are generally regarded as not being cost effective or environmentally acceptable except when the endangered forest resource is of extremely high value.

Control recommendations are made based upon currently available information. Future research may provide improved or alternative control methods. Also, the topic of SPB prevention has received scant attention and further research on this subject is needed. It is recommended that research to develop and improve SPB control and/or prevention techniques be implemented. New methodologies, in addition to being effective in reducing SPB damage, must be both economically efficient and environmentally acceptable.

Recent work on biological control in RWU-SO-4501 indicates a potential for this approach. There are many problems in such research, and if early trials prove successful, the requirements to develop a particular tactic would involve a considerable commitment of resources and personnel.

It has been demonstrated that a predator of the Douglas fir beetle, *Dendroctonus pseudotsugae*, responds readily to SPB pheromone. The predator, *Thanasimus undatulus* Say, is closely related to the native clerid, *T. dubius*, and has been observed to feed on SPB and reproduce to the pupal stage in the laboratory. Because it responds to SPB pheromone, it will probably be able to locate prey in southern forests. A small release made in 1985 in the Kisatchie National Forest has not provided information on the predator's survival potential. Should this predator be able to survive, it might

be an effective predator during the colder periods of the year when the native clerid seems to be inactive.

The objectives of the recommended research are to: (1.) develop methods for preventing SPB infestations, (2.) develop methods for controlling existing SPB outbreaks, (3.) determine the economic feasibility of SPB control and prevention methods. (4.) To determine the environmental impacts of proposed SPB prevention and control methods.

For studies of new and improved direct control and detection methods, the following are recommended: (1.) research on behavioral chemicals, (2.) improvement of SPB detection methods, (3.) research on biological control, (4.) research on host tree physiology relating to susceptibility to SPB attack.

Once research on the above listed items has progressed far enough to determine the effectiveness of the methods for preventing or controlling SPB infestations, it is recommended that the methods be studied to determine their economic feasibility. This determination will require collection of appropriate cost data and the estimation of the anticipated benefits. Also, the methods will have to be studied to determine if they conform to existing federal and state environmental protection laws.

D. Determine the Effects of Various Silvicultural Practices on Insect and Disease Incidence in Older Stands.

Various silvicultural practices have been recommended as a means for preventing or reducing losses from SPB. Many of these practices will be carried out on a planned basis in older stands because (1.) they will achieve long-term multiple use management objectives of national forests and forests in other ownerships across the south and (2.) they will accomplish short-term needs in coping with existing SPB problems.

Cultural practices may also intensify the incidence and impact of disease problems in stands. There is a need to determine the effects of various silvicultural practices on the incidence and severity of diseases in older stands.

Several stem, butt, and root diseases are commonly found in older pine stands. The two most commonly associated with SPB infestations are annosus root rot and littleleaf disease.

Annosus root rot---

Many forest managers regard annosus root rot as a minor pest problem but others regard it as a serious threat to the growth and yield of thinned pine stands on high hazard annosus sites. These differences of opinion need to be resolved. Total losses from annosus on sites of varying hazard need to be determined and compared to yields from healthy stands. The association of annosus root rot with SPB need further study. Annosus and SPB are found together in thinned stands of many ages. Stress from annosus is believed to predispose stands to SPB attack, but the extent of this interaction needs further study. Incidence of annosus root rot needs to be related to intensity of thinning, frequency of thinning, time of thinning, site hazard, and age of the stand. Recommended stump treatments and cultural practices to reduce losses from annosus root rot should be applied on an operational basis during thinning. Information is needed to determine the costs and biological effectiveness of recommended management strategies.

Littleleaf disease---

Littleleaf disease and the SPB are the most serious forests pests affecting conifers on the Piedmont plateau. Losses to these two pests commonly exceed $150 million a year. Littleleaf disease predisposes trees and stands to stress and subsequent attack by the SPB. Interactions among the site, fungus, host trees and SPB have not been adequately studied.

Information on incidence, growth loss, and mortality due to the littleleaf-SPB complex is minimal and dated. Virtually nothing is known about the stress physiology of trees and stands affected by littleleaf disease. The relative resistance of loblolly and shortleaf pines to the littleleaf-SPB complex is poorly understood. The impact of the disease on growth and yield of Piedmont forests deserves more attention. A fuller understanding of beetle-disease-host-site interactions is urgently needed.

E. Determine if There is Genetic Resistance in Pines to SPB Attack.

This item was identified in the prospectus. Although there are some indications that genetic variation in resistance to SPB attack exists, the team believes this approach to SPB control is a low priority for research. This conclusion is based on the long time and large investment required, the problem of developing an adequate supply of resistant planting stock and the low probability of south-wide use. It is also possible that SPB populations will adapt to resistant strains.

Appendix A

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Appendix B

PROSPECTUS

Objective: **Develop long-and short-term SPB strategies for the control and/or prevention of southern pine beetle losses.**

Responsible Officials
Jack Alcock - Regional Forester - R8
Tom Ellis - Station Director - SO

Oversight and Guidance
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WO Liaison
Dick Fitzgerald - Timber Management - WO
Ken Knauer - Forest Pest Management - WO
Gerald Anderson - Forest Insect and Disease Research - WO

Core Team
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Core Team Support Group[1/]
Bob Bridges - Research Entomologist - SO
Richard Birdsey - Research Forester, FIA - SO
George Ryan - Statistician, FPM - R8
Dick Field - Research Analyst - SE
Paul Mistretta - Plant Pathologist, FPM - R8
Rodney Busby - Economist - SO
Kirby Brock - Team Leader, SPB EIS - R8
Jim Perry - OGC - WO

[1/]Additional support group members may be identified to participate as the Core Team work progresses.

Critical Due Dates
Short-Term Strategy Report Complete. . . . December 19, 1985
Long-Term Strategy Report Complete . . . .March 15, 1986

Objective: Develop long-and short-term strategies and tactics for suppression and/or prevention of losses/damage caused by southern pine beetle on National Forest land.

1. Develop strategies that can be used for the current outbreak and where appropriate incorporate into final SPB-EIS.

2. Under short-term strategies, evaluate priorities for funding projects and managerial/administrative procedures. Develop action plan for implementing guidelines during the current outbreak.

3. Identify and evaluate long-term strategies which will reduce southern pine beetle-caused losses. Develop an action plan for implementing these strategies.

4. Identify research and application needs that would aid resource managers to improve their prevention and suppression strategies for managing the southern pine beetle. Make recommendations to Forest Insect and Disease Research & Forest Pest Management.

A. ADDRESS IN EIS

1. History of current and past epidemics

2. Criteria currently used to determine effectiveness of control

3. Cost-benefits of individual treatment methods on a spot basis

4. Current control tactics and their effectiveness

5. Determine the likely course of the epidemic

6. Impact of treatment on regeneration and fuel loading (fire)

B. SHORT-TERM STRATEGIES

1. Determine the best suppression strategies and tactics for controlling the SPB in the South considering:

   a. Availability of funds
   b. Effectiveness of treatment method
   c. Value of resource

d. Market conditions
e. Adjoining ownerships
f. Political considerations
g. Administrative considerations & constraints

2. Prepare guidelines on No. 1 above.

3. Develop a plan to determine the increase in number of new spots and acceleration of existing spots associated with specific treatment methods.

4. Validation of stand risk rating system(s) relative to initiation of the current epidemic.

5. Identify best available technology and implement strategies to prevent or reduce timber losses during the current epidemic:

a. Initiate SPB hazard rating on all appropriate National Forests not currently rated.
b. Initiate silvicultural treatment in high hazard stands where SPB is not currently in outbreak status.
c. Continue to initiate rapid control of all SPB infestations on a priority basis.
d. Evaluate "Report of Log Storage Work Group" on feasibility of water storage of beetle-killed timber. Determine the need for a pilot project.
e. Improve record keeping requirements for SPB spots and treatment efforts.

C. LONG-TERM STRATEGIES

1. Determine the cost of control/prevention vs. the value of the resource at risk on an areawide basis.

2. Evaluate need for modification of Land Management Plans to lower the risk of high hazard stands by:

a. Shortening the rotation age.
b. Decreasing the stocking levels (need to determine effects of intermediate harvest on 40-60 years stands.)
c. Regenerating alternate species or changing species composition.
d. Increasing the use of hardwood buffers.

3. Develop a plan to determine effects of rapid salvage removal or other treatment of all active

infestations during endemic periods to prevent or reduce losses from epidemics (pilot project)

4. Improve the detection and monitoring of SPB infestations during endemic years and improve record keeping systems.

D. RESEARCH NEEDS

1. Evaluate and quantify the phenomenon of spot proliferation.

2. Continue research on the incidence of blue stain and its relationship to SPB outbreaks.

3. Improve population dynamics studies to determine if SPB microorganism complex can be used to predict the increase and collapse of SPB populations.

4. Determine the effect of various silvicultural practices on disease incidence in older stands.

5. Determine if there is genetic resistance in pines to SPB attack.

6. Determine the conditions that trigger an epidemic and subsequently cause it to collapse.

7. Develop a predictive method to identify increases or decreases of SPB populations from one year to the next.

8. Continue to improve or develop control techniques giving priority to economically feasible, environmentally acceptable approaches and longer-term preventive control.

SHORT-TERM STRATEGIES
FOR
MANAGING SOUTHERN FORESTS TO REDUCE SOUTHERN PINE BEETLE IMPACTS

Prepared by the following
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TABLE OF CONTENTS

I. INTRODUCTION

Region 8 has experienced a severe outbreak of southern pine beetle (SPB) activity on some National Forests for the past three years. In 1982 and 1983 the National Forests in Texas developed epidemic situations. The current outbreak now affects Texas, Louisiana, Mississippi and Alabama. Arkansas, South Carolina and Georgia are affected to a lesser extent.

In the winter of 1984 and early spring of 1985, the situation in Texas appeared to improve. Some Texas land managers were encouraged by an apparent decrease in SPB numbers. However, these indications proved deceptive and the problem quickly resurfaced, resulting in the most costly summer in the recorded Texas history of the SPB. By mid-July, the number of SPB spots in Texas had already surpassed the maximum annual record -- this with months of peak beetle activity still remaining. As of October 1, 1985, three States alone (Texas, Louisiana, and Mississippi) had tallied over 40,000 separate infestations involving 1 billion board feet of timber. Converted to lumber, this volume represents enough wood to build 100,000 homes of 1,800 square feet each. Table 1 outlines the situation in more detail.

The epidemic shows some evidence of subsiding in Texas, but is intensifying in Alabama. Georgia and South Carolina also report widespread areas of intense new beetle activity on national forest land as well as on other ownerships. The Ouachita National Forest recently reported spots both inside and outside wilderness areas. Land managers from Louisiana through the Piedmont expect heavy losses in 1986. Table 2 summarizes FY 85 expenditures and table 3 summarizes estimated expenditures in FY 86.

Table 1 -- Estimated number of SPB infestations from September 30, 1984 - October 1, 1985.

State	National Forests	Other Ownerships	Total
Louisiana	4,535	16,000	20,535
Mississippi	2,538	1,400	3,938
Texas	5,885	8,930	14,815
Georgia	500	649	1,149
Alabama	410	1,362	1,772
South Carolina	117	2,643	2,760
Arkansas	0	435	435
Totals	13,985	31,419	45,404

Table 2--FY-1985 SPB Expenditures (I&DC only)

National Forest	$4,600,000
States (Federal share)	731,000
State share	98,000

Totals do not include salvage sale or other funds used for SPB suppression on the National Forests.

Table 3--Estimated FY-1986 SPB Expenditure (I&DC only)

National Forest	$2,700,000 1/	1/ Actual needs are projected to be 6 Million Dollars.
States (Federal share)	950,000 1/	
State share	1,200,000	

Although the SPB had been a pest of southern forests for many decades, the Forest Service did not establish a formal research program on this insect until the early 1960's. Both the Southern and Southeastern Stations conducted relatively limited studies, in the mid 1960's, work was increased principally at Pineville, LA in the Southern Station and Research Triangle Park in the Southeastern Station. In the early 1970's, work increased at Pineville, and by agreement with the Washington Office, the Southern Station became the lead Station for research on the insect, however this was still a relatively small effort of five SYs.

With increasing number and expanse of southern pine beetle infestations across the South, an Expanded Southern Pine Beetle Research and Applications Program was initiated in the Secretary's office in USDA. This Program operated from 1974-1980, and at its conclusion another Program, broader in scope, was initiated to take advantage of new information. This Program, first operated out of WO-Research and later transferred to the Southern Station, was named the Integrated Pest Management Research Development and Applications Program for Bark Beetles of Southern Pines. It was terminated at the end of FY 85. Both these programs involved large coordinated research and development efforts, mostly in the university sector, with a strong commitment to technology transfer. Current Forest Service and university research efforts are approximately at the pre-1974 level.

Many of the management recommendations in this document take advantage of research and other information gained over the last 20 years. But in any complex biological system that man wishes to regulate, there are important gaps in knowledge which will have to be filled, or hypotheses tested in order to develop a more rapid response on the one hand, and a longer-term solution on the other. These needs are touched upon in this short term report, but will be examined and spelled out in more detail, with recommendations, in the subsequent long-term report.

In response to the extreme severity of the situation, the Chief of the Forest Service called for the formation of a team to develop both long and short-term strategies for the control and prevention of timber losses from SPB. The specific charges to the team were:

-- Develop strategies that can be used for the current outbreak, and where appropriate, incorporate these strategies into the final SPB-EIS.

-- Under short-term strategies, evaluate priorities for funding projects and managerial administrative procedures. Develop an action plan to deal with the current outbreak.

-- Identify and evaluate long-term strategies to reduce SPB caused losses. Develop an action plan for implementing these strategies.

-- Identify research and application needs that would aid resource managers to improve their prevention and suppression strategies for managing the SPB. Make recommendations to Forest Insect & Disease Research and Forest Pest Management.

This document presents the recommendations of the Core Team. Although they are directed primarily at "short-term" strategies, several set the stage for "long-term" strategies. Recommendations are based on the Core Team's examination of available research, operational data, and draw from the experience of the team and those providing guidance and support. A second document will discuss long-term strategies and research needs.

We believe that successful management of the SPB problem requires (1) long-term silvicultural treatment of national forests to lower stand susceptibility, (2) continuous monitoring, and (3) aggressive suppression action during initial stages of an epidemic. This will involve some major changes in current management direction. Suppression activities may have to be modified according to guidelines recommended in this report. In their deliberations, team members agreed to certain conclusions and recommendations.

-- Additional cost effective measures can be implemented to reduce resource losses.

-- There are times and places during outbreaks when large expenditures for cut-and-leave or chemical treatments may not be justified. This could involve situations where epidemics are declining or when the outbreak has become so aggressive that treatment methods other than cut-and-remove may not be cost-effective.

-- Current recommendations are to treat infestations for protection of red-cockaded woodpecker colonies and foraging areas, recreational areas and state and private lands, etc. (see SPB-DEIS for minimum work that will be done). In all cases where markets and management objectives allow, the cut-and-remove method should be continued.

-- When more than one infestation per 1000 acres of host type occurs, an epidemic may exist and suppression action should be immediate. Infestations should be systematically controlled while they are still small. There is a high probability of preventing or minimizing significant losses while continuing to achieve overall management goals.

-- The risk of severe damage can be somewhat reduced by regulating stand density through routine thinnings. For this to be highly effective, thinnings must start early in the life of a stand. It does not appear that thinnings in stands 50 years or older will improve individual tree vigor or otherwise change conditions enough to significantly change beetle losses. Further research is needed on optimum densities for stands over 50 years old.

-- Insecticide use will retard spot growth and may be effective for protecting small, high value stands or urban trees. Due to high costs and environmental concerns, this does not appear to be a practical measure for reducing damage over large areas during epidemics.

-- Specific administrative and managerial concerns that cannot be handled at the Region, Forest or District level need to be advanced through channels for resolution. In some cases new legislation may be required.

-- Information needs and technology transfer will be improved through scheduled meetings of Southern Region, Southern and Southeastern Station personnel. Such meetings are critical in both epidemic and endemic situations.

-- Administrative problems and solutions encountered during the current outbreak have been documented and should be made available to other Forests.

Section II presents the Action Plan. Section III includes some of the background used by the team to develop the Action Plan.

II. ACTION PLAN (Short-Term)

A. Determine and Implement the Best Suppression Strategies and Tactics for Controlling the SPB in National Forests and Use Appropriate Guidelines.

Action Item 1 - Establish a Regional Policy for allocating I&DC funds for SPB suppression projects.

a. In most instances SPB suppression is most effective when the outbreak can be controlled before it expands into a Forest-wide epidemic. Consequently, the following criteria will be used as guidelines to prioritize project funding in decending order of priority.

(1.) New outbreaks which are rapidly expanding.

(2.) Existing outbreaks which are continuing to expand.

(3.) Existing outbreaks which are static.

(4.) Existing outbreaks which are declining.

b. These criteria are directed towards ID&C funds, Forests should continue to cut-and-remove (salvage) infested spots with Salvage Sale Funds (SSF) using the same criteria.

c. Input from the Forest and involved staff units will be solicited. In addition, economic, legal and political considerations will be considered before final allocation of I&DC funds.

d. A computer-based model to help allocate suppression funds is proposed in Action item A-4.

Who: Regional Forester

When: 5/86

Action Item 2 - Implement a Region-wide priority system for treatment of infested spots.

Continue to use the computer-based program which utilizes two systems for priortizing spots: (1) The control priority guideline in Table 1 of Agriculture Handbook 575 (See Appendix C) which uses the number of freshly-attacked trees, total number of active trees, pine basal area and timber size to assign a treatment priority,and (2) the Texas Forest Service Spot Growth Model which uses number of active trees, total basal area and number of freshly-attacked trees to predict the number of additional trees killed during the next 30 days.

After ranking the spots with the computer program, use the following criteria to assign treatment priority:

a. Control active spots to prevent harm to active RCW colonies when the evaluation predicts the spot will adversely impact an RCW colony including foraging area, within 30 days.

b. Control active spots in wilderness areas that are within 1/4 mile of state and private lands. Control will begin when the evaluation predicts spot will adversely impact that property.

c. Control active spots on other National Forest lands that are predicted to adversely impact state and private lands, with first priority to protect developed sites.

d. Control active spots within or adjacent to and threatening established National Forest or other federal recreation areas or other high value administrative sites.

e. Control active spots (high or medium priority) which threaten high value timber resources considering: vigor of SPB population, forest conditions (SPB habitat), market conditions, and political considerations.

f. Control remaining active spots.

Who: Regional Forester

When: 3/86

Action Item 3 - To increase the overall effectiveness of treatment methods use the following recommendations:

a. Cut-and-remove is usually the most cost-effective method. Utilize this method whenever possible. Monitor markets closely and make timely price adjustments to assure its availability.

b. Achieve a time lag of 28 days or less between spot detection and initiation of treatment to improve efficiency of treatments.

c. Increase detection and treatment efforts during winter-spring months as these active spots normally contain high brood densities which will disperse to initiate new spots if left untreated.

d. During periods when the ground is excessively wet high priority spots should often be treated even if some soil damage occurs. Evaluate each spot carefully to determine current and potential timber resource loss versus soil damage.

e. Use the following strategies and tactics when cut-and-remove method cannot be used.

(1.) During the period May-October follow current guidelines for cut-and-leave.

(2.) During the period May-October when there are a large number of spots in close proximity to one another stratify the District (Forest) into discrete treatment blocks (minimum of 1000 acres) Use cut-and-leave methods, with the objective of treating all spots (moderate-high priority) in the block within 30 days. All combinations of treatment methods may be used as long as the total block is treated.

(3.) Use cut-and-leave from November through April only after consultation with an entomologist.

(4.) Increase use of chemical treatment alternative in spots (up to 100 active trees) from November through April.

(5.) Use chemical treatment on breakouts when it is more cost-effective than cut-and-leave.

Who: Regional Forester

When: 6/86

Action Item 4 - Improve use of economic analysis in allocation of SPB suppression funds.

Develop a budgeting technique based on a modified version of the deSteiguer-Hedden Beetle Economic Analysis Model (BEAM). The model presently simulates SPB damage on forested areas given a certain level of beetle population. Control strategies (detection, evaluation and suppression) are applied to the areas of SPB damage, and the model determines the economically optimal level of control expenditure.

The optimal level of control expenditure and benefit/cost ratios for National Forests are aggregated to the state level. Ranking of B/C ratios may provide another tool for requesting and allocating SPB control funds. It is recognized that this information is just one consideration that may be useful in the allocation process.

Who: SE Station
RO - Forest Pest Management

When: The study is complete and approximately one month is required to write report (3/86).

B. Administrative and Managerial Recommendations

Action Item 1 - Appropriate forests will prepare a SPB Emergency Manning Plan. Ensure I&DC responsibilities are included in specific position descriptions and performance standards at Forest and District levels.

a. Each district needs an ongoing SPB coordinator.

b. Establish threshold criteria to indicate when the SPB outbreak is a Forest emergency. Generally, this is when more than one District is affected or the magnitude is more than a single District can handle.

c. When FPM & District Ranger concur that an emergency exists, the Supervisor's Office will be notified.

d. If the SO concurs, they will have three days to implement a SPB Emergency Manning Plan.

(1.) Notify Regional Forester of the magnitude of the problem.

(2.) Formal declaration that SPB control is first priority on Districts with outbreaks.

(3.) Implementation of the District SPB Suppression Organization and SO SPB Suppression Organization as required. (See Appendix C & D).

(4.) Regional Forester will notify Forest Supervisor and other Forests concurring in declaration of a SPB emergency.

Who: Forest Supervisors and District Rangers

When: 6/86 and as needed

Action Item 2 - When the Regional office declares a SPB emergency, all Forests will provide detailers to the SPB-impacted Forests as requested.

a. Forests may have to request adjustments in meeting established targets.

b. Minimum tours of duty for detailers are recommended. (See Appendix E).

c. Use the Regional Fire Dispatch system to coordinate and assign detailers between Forests.

d. Include recommended tours of duty in the SPB Emergency Manning Plan.

Who: Regional Forester
Forest Supervisor

When: 4/86 & continuing

Action Item 3 - Designate a team composed of personnel from Fiscal and Accounting, Planning and Budget, Timber and Forest Pest Management to determine the availability of all funding resources which currently exist to support SPB suppression efforts. Transmit this information with guidelines to field units.

Who: Regional Forester

When: 7/86

Action Item 4 - Recommend that the W. O. encourage legislation to allow expenditure of I & D C suppression funds sinilar to the use of FFF for fire emergencies.

Who: Regional Forester

When: 6/86

Action Item 5 - Using available technology, develop and implement an automated obligation tracking and cost projection system for SPB suppression funds.

Who: Regional Forester

When: 12/86

Action Item 6 - Evaluate and revise current procedures relating to suppression project proposals and eventual funding to reduce lag time.

Who: Chief

When: 7/86

Action Item 7 - Increase District Ranger's sale authority to expedite movement of timber in emergency situations for both advertised and nonadvertised sales.

Who: Chief

When: 7/86

C. Develop a Plan to Determine the Increase in Number of New Spots and Acceleration of Existing Spots Associated With Specific Treatment Methods.

Action - Implement a pilot project to determine the efficacy of treatment strategies by determining the rate of growth and spot proliferation around treated versus untreated infestations.

This project is expected to produce the following information:

(1.) The number of spots proliferated around each treated and untreated spot.

(2.) Increase in spot size over time may be calculated using a geographic information system. Effects of treatment versus nontreatment can be compared.

Who: So. Station
SE. Station
RO - Forest Pest Management

When: Initiate 7/86
Complete 6/87

Cost: Estimated $40,000 for FY 1986.

D. Validation of Stand Risk Rating System(s) Relative to Initiation of the Current Epidemic.

Action - The hazard rating system being used on National Forests in Louisiana, Texas, and Mississippi will be validated by using existing records from two Districts on each Forest.

SPB spots will be tallied by stand in which they occurred and compared to the SPB risk rating assigned by NF Risk. These numbers will then be converted to number of spots/1000 acres of risk class.

The following districts will be used to validate NF Risk: Evangeline, Catahoula, Bienville, Bude, Trinity, and San Jacinto. This choice provides for validating risk on Districts with a lower level of SPB activity and on Districts with a much higher level of activity.

Individual SPB spot records are not available by stand for Districts outside these three states. Further validation of hazard rating systems will be done as information becomes available in other locations.

Who: RO - Forest Pest Management
So. Station
SE. Station

When: Initiate immediately where information is available
Complete by 6/86

E. Initiate SPB Hazard Rating on All Appropriate National Forests Not Currently Rated.

Action - Regional Forester direct the following Forests to initiate SPB hazard rating: Ouachita, Francis Marion-Sumter, National Forests in Alabama and Chattahoochee-Oconee. The following priorities are recommended:

Alexandria Field Office Zone

(1.) NF in Alabama
(2.) Ouachita NF

Asheville Field Office Zone

(1.) Unrated Sumter Districts
(2.) Francis Marion NF
(3.) Croatan NF
(4.) Uwharrie NF
(5.) Appalachicola NF

When: 3/86 initiate
in place by 10/86

Who: RO - Forest Pest Management
Timber Management
Forest Supervisors
So. Station
SE. Station

F. Initiate Silvicultural Treatments in High Hazard Stands Where SPB is Not Currently in Outbreak Status.

Action - Regional Forester direct appropriate Forests to initiate silvicultural treatment in high hazard stands with available funds (FY 86) and submit funding needs above current programs.

Who: RO - Timber Management
Appropriate Forests

When: 6/86

G. Implement Rapid Control of All SPB Infestations on a Priority Basis.

Action Item 1 - (see items A&B).

Action Item 2 - A pilot project will be developed for inclusion in long-term strategies for silvicultural and suppression treatments on an area-wide basis during endemic periods.

H. Evaluate "Report of Log Storage Work Group" on Feasibility of Water Storage of Beetle-Killed Timber. Determine the Need for a Pilot Project.

Action - The team recommends that a pilot project not be implemented. This is based on our review of available information and the document "Report of Log Storage Work Group on Feasibility of Water Storage of Beetle-Killed Timber".

I. Improve Record Keeping Requirements for SPB Spots and Treatment Efforts.

Action - Regional Forester issue a FSM supplement establishing minimum SPB spot record keeping requirements that cover both endemic and epidemic periods.

Who: RO: Timber Management
Forest Pest Management
Forest Supervisors
Southern Station
Southeastern Station

When: 9/86

J. Improve Cooperation/Communication Between the Region and Stations About SPB Activities Including Information Needs, Information Availability, Coordination of Efforts & Out Service Contacts.

Action Item 1 - Regional Forester and Station Directors establish a team composed of Regional Office, Station(s) and Forest personnel that will periodically address the above issues.

Who: Regional Forester
Director, Southern Station
Director, Southeastern Station

When: 3/86

Action Item 2 - The team established by the above action will submit their recommendations to the Regional Forester & Station Directors.

Who: Team

When: Continuing

III. ACTION PLAN BACKGROUND - SHORT-TERM STRATEGIES

This section summarizes information used by the team to develop the action plan for short-term strategies.

A. Determine the Best Suppression Strategies and Tactics for Controlling the SPB in National Forests Considering: Availability of funds, effectiveness of treatment method, value of resource, market conditions, adjoining ownerships, political considerations, administrative considerations and constraints and prepare guidelines.

1. Treatment Priorities

Currently, treatment priorities are established by entering SPBIS data on "recordkeeper" (a data base management program on the Apple computer). Another program accesses this data and ranks the active spots as high, medium or low priority for treatment. In addition, a projection is made of additional tree mortality which will occur over the next 30 days. The system is apparently working well. However, other considerations should be used when establishing control priorities. These include:

a. Red-cockaded woodpecker colonies.

b. Threat to state and private lands that contain developed sites.

c. Threat to state and private lands.

d. Threat to National Forest and other federal recreation areas or other high value administrative sites.

e. Value of the timber resource being protected and potential for continued or increased SPB activity in the area.

Availability of funds to suppress southern pine beetle epidemics may be a limiting factor in the near future. The Region and Forest(s) have to efficiently and effectively utilize the best combination of Insect and Disease Control Funds, Salvage Sale Fund, and Reforestation and Timber Stand Improvement funds. Each funding source has certain restrictions on how it may be used. It is imperative that a well thought out operations plan be developed which considers all biological, environmental and administrative considerations and constraints. Various sections of this document address this concern.

2. Effectiveness of Treatment

In the West Gulf Coastal Plain the highest SPB survival occurs in trees infested from fall through early spring. The severity of SPB outbreaks is greatest in the spring with the lowest survival and activity occuring during the summer months (Thatcher 1967, 1971, 1974; Thatcher and Pickard 1964). Thatcher and Pickard (1967) recommend intense control activities during the fall, winter and spring.

There is some evidence that applying either rapid salvage or chemical control on an area-wide basis may reduce losses to the SPB (Morris and Copony 1974; Lorio and Bennett 1974). Morris and Copony in their one-year study reported a 30 percent decrease in spots per 1000 acres in an area which received intensive salvage compared to a 30 percent increase in the check area. Lorio and Bennett reported

that when nearly 3000 infestations were treated over a 5-year period the average spot size was only 3.4 trees per infestation.

Cut-and-leave is an operational control technique that provides an easy to implement treatment for preventing spot spread in small to medium-sized spots (<100 trees) when salvage is not feasible. It requires a minimum amount of equipment, manpower, and can be rapidly applied (Swain and Remion 1981). It has been used by the Texas Forest Service since 1970. The average lag time from detection to control by cut-and-leave is considerably less than that for salvage (Texas Forest Service 1980). This time lag becomes an important consideration when a Ranger District has a large number of spots to treat. Cut-and-leave is now recommended for use by the USDA Forest Service and all State Forestry organizations in the Southern Region.

In practice, effectiveness of cut-and-leave treatment has been evaluated on the basis of subsequent spot growth observed following treatment of individual spots. It has not been possible to determine the extent of beetle dispersion or evaluate satisfactorily the degree of association of subsequent beetle infestations with treatments.

The rationale for cut-and-leave is based on evidence that spot growth is disrupted when a buffer strip is included in the treatment (Ollieu 1969), Billings 1980). Billings points out that experimental tests of cut-and-leave did not justify its application solely on that basis (Hodges and Thatcher 1976, Palmer and Coster 1978, Hertel and Wallace 1980). He indicates that the biological rationale for spot disruption by cut-and-leave is based on the idea that spot growth in the summer requires emerging beetles, nearby pine trees, and a source of secondary attractant. By felling the most recently attacked trees, it is thought that the attractant source is eliminated (Vite' and Crozier 1968), the nearby pines are eliminated with the buffer strip, and beetles are expected to disperse under these conditions (Gara 1967). Because beetle energy reserves are known to be low in the summer (Hedden and Billings 1977), dispersing beetles may die in search of susceptible hosts. Research on the fate of dispersing beetles has been inadequate to satisfactorily evaluate their fate. Recent observations in Louisiana indicate that during the winter beetles may not always disperse from cut-and-leave treated spots.

The current recommendation for cut-and-leave is to use the technique when necessary during the months of May through October, but when there are many active infestations within the treatment area it is possible that dispersing beetles could immigrate to them and increase spot growth. This result could be a disadvantage in using the technique, and Billings (1980) points out other disadvantages such as the need for a buffer strip of green trees that can be disproportionately large for small spots, and the greater likelihood of "breakouts" when applied to expanding large spots.

The effectiveness of individual spot treatment is based on the supposition that a treated spot did not have additional spot growth, i.e., a breakout. There is no attempt to account for spot proliferation or effect on beetle populations.

A post suppression evaluation (Smith and Connor 1985) of an FY 1984 SPB suppression project for the National Forests in Texas reported that only 23 percent of the spots "broke out" (i.e., 77 percent of the infestations were treated successfully on the first treatment).

An analysis of suppression data for the National Forests in Texas from October 1984 through May 1985 indicated 1,038 SPB spots were treated with cut-and-leave and 1,852

spots were treated by cut-and-remove. Seventy-seven percent of the cut-and-leave spots and 89 percent of the cut-and-remove spots were successfully treated with the first treatment. Chemical treatment, if applied correctly is assumed to be effective. However, it was rarely used, accounting for 0.1 percent of the treated spots.

The current recommendation is to use cut-and-leave from May to October. There is still concern about using cut-and-leave during this period when there are a substantial number of active spots within the treatment area. It is hypothesized that although the treatment is effective in stopping spot growth that surviving emerging adults will respond to the pheromone of a nearby existing spot and accelerate the growth of that spot. Also, cut-and-leave has been used on large spots from October through April when spot proliferation is occurring. The rationale for treatment during this time of year is that large spots will continue to rapidly expand and, by forcing the beetles to disperse, will reduce the total losses and enable the treatment of the smaller proliferated spots.

Various treatment efforts will be further addressed in long-term strategies and research needs.

3. Allocation of SPB Control Funds

Each year, funds are made available to the USDA Forest Service to control SPB outbreaks on the National Forests. Some of these funds must be immediately set-aside to control SPB infestations that will affect environmentally sensitive areas. However, beyond these required allocations, no method exists for determining priorities to control SPB outbreaks that threaten the commercial timber resources on the National Forests.

The problem of allocating scarce funds among competing interests is one typically dealt with in standard financial management text books. The solution is to conduct a benefit/cost analysis and to allocate funds to those projects with the largest benefit/cost ratios (Brealey and Myers 1981). Thus, the purpose of this proposal is to provide benefit/cost information to assist in the allocation of SPB control funds to the National Forests. It is recognized that benefit/cost information is only one of several criteria which will be used to allocate funds.

A regional economic analysis of SPB control has been conducted by de Steiguer and Hedden (1985), and the results of this study can provide additional information that would be useful for allocation of funds to the National Forests. This study simulated SPB damage and control for commerical timber stands across the entire South. Available results provide information on the optimal level of SPB funds needed to control damage, and the expected benefit/cost ratios. These results are available for the National Forests aggregated to the state level for each of the southern states. Further research and analyses, under the "Long-Term Strategies" will be needed before benefit/cost ratios can be provided at the individual National Forest level.

B. Administrative Considerations and Recommendations

The current SPB outbreak has pointed out problems that hinder efforts to engage in a forest insect or disease situation of epidemic proportions. These areas must be addressed to assure (1) cost-effective efforts during outbreaks, (2) that personnel involved in future outbreaks do not have to "recreate the wheel",(3) an established system is in place to cope with what can become a crisis situation and (4) that

administrative and legislative needs that would ease the administrative and procedural tactics for engaging in a forest insect or disease situation of epidemic proportions.

We, as an agency, have developed, become familiar with and dealt with other "crisis" situations (i.e., fire control, floods, hurricanes, tornadoes, etc.). Current experience with SPB indicates that our capability to successfully face other dilemmas has not been transformed into a common approach for insect epidemics. Existing procedures and available skills have not been adequately utilized.

The National Forests in Texas recently brought together personnel intimately involved with their current epidemic. Their concerns, problems, ideas and recommendations need to be captured, implemented and/or submitted for higher approval for implementation. This document highlights the experience of those who were involved in the Texas outbreaks. The items following are the keys (as surmised by the core team) to an effective suppression operation. (A complete set of the material can be obtained by contacting the NF in Texas).

-- It appears that current procedures are not adequate to alert District Rangers or Forest Supervisors that an emergency is emminent or even exists. By the time the problem gets everyone's attention we are often playing catch up.

-- Proposals contained herein provide line officers and their staff with the information to prevent the "surprise." They promote and provide for prevention, detection and suppression. Their normal use will enable early detection and suppression and will alert decisionmakers when a particular situation is reaching outbreak proportions.

-- Discussions revealed that several administrative problems impacted the efficiency of the control effort. One example was the difficulty in obtaining detailers because of other Supervisors' concern over meeting their own targets. This existed for a few months until the Regional Forester issued a letter giving priority to SPB and saying targets would be negotiable. Details being limited to two weeks was consistently mentioned as a problem. By the time the detailer learns his/her way around, the detail is up and the person leaves.

-- One of the most telling comments heard was that when project personnel needed something the answer was too often, "It can't be done." That answer would stick until the problem got bigger and the pressure to solve it reached the point where a way was found to solve it.

-- Discussions also revealed that a Project Manager needs to be assigned, made responsible for all aspects of the project and relieved of other responsibilities.

-- Accounting systems are a critical problem. Projections of existing balances and future money needs seem to change abruptly and sometimes questions of priorities arise. A system that keeps track of expenditures and can be updated quickly needs to be in place. In addition, Regional priorities for the different funds-- need to be set and reviewed periodically to obtain the most effective use of these funds.

-- Contractors must be paid in a timely fashion. Late payments are a deterrent to contractors to continue working for the Forest Service.

-- Follow-up treatments need to be prescribed and the work included in programming and budgeting. These treatments need to consider erosion control measures, safety (snag-free) corridors along trails or adjacent to recreation areas, fuel reduction, site preparation and reforestation requirements.

-- It is the team's opinion that a version of the Incident Command System could have prevented many of the problems that occured. This is based on the fact that the system is in place with its procedures. Furthermore, it draws upon a Forest or District available expertise and identifies the expertise that must be obtained from other sources.

C. Develop a Plan to Determine the Increase in Number of New Spots and Acceleration of Existing Spots Associated With Specific Treatment Methods.

The SPB continues to be the most damaging forest pest throughout the South. An outbreak has been ongoing in East Texas since late 1982. Control projects have been initiated to reduce timber losses caused by the SPB. Within the National Forests two primary techniques are employed for SPB control, these are cut-and-leave and cut-and-remove SPB infested trees. This project will attempt to determine the efficacy of these two treatment strategies by determining the rate of spot growth in existing infestations and spot proliferation around treated versus untreated infestations. It will also be used as a pilot study to assess the utility of using geographic information systems (GIS) as a geographic data base to monitor the trends and status of the SPB as well as hazard rate stands within the area of the study. The objectives are to:

a. Determine the difference in the amount of spot growth between treated versus untreated spots.

b. Determine the difference in spot proliferation as measured by the number of spots adjacent to treated versus untreated spots.

c. Develop a computerized geographic data base to monitor SPB status and trend over time.

d. Develop guidelines for the use of a computerized geographic data base to hazard rate sites for control priorities and potential losses caused by SPB.

SPB control projects have been in progress on the National Forests in Texas for two years. Proposed ranger districts for implementing this project are the Trinity Ranger District on the Davy Crockett National Forest and the San Jacinto Ranger District on the Sam Houston National Forest.

Interpretation of aerial photographic coverage over these two ranger districts to delineate locations of SPB infestations will serve as base line data for this evaluation. Four complete sets of photographs taken over a one-year time period acquired or available for the evaluation are as follows:

-- Panaromic optical bar color infrared, scale 1:38,500. Flown September 14, 1984.
-- 9 X 9 format, scale 1:24,000, color infrared. Flown May 1985.
-- 9 X 9 format, scale 1:20,000, color infrared. Flown November 1985.
-- Panaromic optical bar, color infrared, scale 1:38,500. Flown December 1985.

These four sets of complete photographic coverage will be interpreted to identify the locations of SPB spots within the two ranger districts. All photographic

interpretation will be transferred to 7 1/2 minute 1:24,000 scale topographic quad sheets. Fourteen sheets will be required to cover the San Jacinto Ranger District and twelve quad sheets will be required to cover the Trinity Ranger District. Following the completion of photographic interpretation and map transfer, all SPB spots recognized as polygons on the quad sheets will be digitized and entered into a computer data base for analysis by MOSS (map overlaying statistical system) GIS installed on a Data General MV-4000 located at the FPM Doraville Field Office.

Compartment and stand boundaries will also be transferred to the 1:24,000 base series maps for data entry and GIS analysis along with ownership and administrative boundaries. Therefore the following attribute themes will be available on the data base:

-- SPB spot location for four dates.

-- Compartment boundaries.

-- Stand boundaries.

-- Ownership and administrative boundaries.

Additional data themes such as transportation networks and topography may be required. Southern Pine Beetle Information System (SPBIS) information will be used to compare treatment practices applied to each spot identified from the four sets of aerial photography.

Previous research has indicated that new spot proliferation is most evident during the period of November through April and that spot growth is more predominant during the period of May through October. The computerized data base and GIS software will then be used to create a one-quarter mile radius buffer around the identified spots to determine the number of spots which have proliferated from existing spots during the period of May through October and a one-half mile radius will be generated around those spots identified as new infestations during the period of November through April. In addition, the increase in spot growth i.e. the difference in size (area in acres) for a spot identified at one point in time will be compared to the same spot at a later point in time to determine the rate of spot growth. This information will then be compared to the SPBIS data to determine the relative effectiveness of the treated versus nontreated spots.

One objective is to assess the relative effectiveness of cut-and-leave versus cut-and-remove by comparing the number of new spots within a certain distance of a given spot within a specific time. The following information available from SPBIS data may be used in the statistical analyses described below: month (of treatment), spot size (trees treated for cut-and-leave, volume for cut-and-remove), total and pine basal area.

For each treatment for each subject area (i.e., location within a predetermined distance of the selected sample spot), the number of new spots within a certain time may follow some stochastic process (specifically as determined by the actual data). Essentially, a statistical distribution will be simulated for each of the treatments. These distributions can be used to determine the relative effectiveness of each of the treatments.

Since the SPBIS data is "operational" in nature, several problems may arise. These include but are not limited to:

a. This is not a controlled experiment; i.e., spots cannot be "paired" or otherwise combined to eliminate the possible influence of factors other than the individual treatments.

b. Since a fixed distance is considered within each spot, the potential host area around each sampled spot may vary.

c. Errors of omission and commision in the interpretation, plotting and transfer of spot locations will become evident upon analysis of the geographic data at each point in time.

d. Mixed ownerships.

e. In heavily infested areas it will be difficult to assign new spots to an existing spot.

Due to these difficulties, it is also desirable to identify (through discriminant or other analyses) the major variables that influence proliferation of SPB spots with respect to the efficacy of the individual treatments. FPM has been using this type of analysis to analyze spot growth data.

D. Validation of Stand Risk Rating System(s) Relative to Initiation of the Current Epidemic.

An important attribute of a pest management system is the ability to predict when and where a pest outbreak will occur. SPB hazard rating may be considered as the part of this system which will identify where SPB is most likely to occur (Hedden 1981). Areas can then be selected for early or timely treatment to reduce the potential of SPB losses. This can be done either through prevention before SPB losses occur or through concentration of control efforts when SPB infests the area. Hazard rating may be used to: 1) help forest managers keep the potential SPB problem in mind, 2) assess outbreak and loss potential, 3) monitor pest activity during endemic periods (efforts can be concentrated in high hazard areas reducing survey costs), and 4) set priorities when scheduling direct control treatments (Mason et al. 1985, Lorio and Sommers 1981).

There are seven SPB hazard rating models recommended by physiographic region for use in Region 8 (Mason et al. 1985). For a status of hazard rating implementation by National Forest see status of hazard rating on the National Forest.

Validation of a hazard rating system may be conducted either before or after the system has been put into practice. There are 3 levels of accuracy that can be used when validating a model: 1) test the model against data from which it was developed, 2) test the model with a subset of the original data which was set aside for this purpose and not used in developing the model, or 3) test the model on a completely new set of data (Hedden 1981). Obviously, a model should perform well when tested against the data used in its development. Even if a model tests well against a subset of the original data it still might not predict correctly if the conditions under which it was developed change. Therefore, the most powerful test of a model would be to validate it against a completely new set of data.

There are some problems encountered when validating a hazard rating system. High hazard stands are not the only ones infested by SPB and not all high hazard stands become infested. Also, the distribution of beetle spots changes as beetle

populations increase and decrease. When SPB activity increases spots become normally distributed among all hazard classes (Mason et al. 1981). This distibution problem can be compensated for by measuring activity against an index of spots per 1000 acres of hazard class instead of an actual count of spots by hazard class.

NF Risk has been validated in Louisiana and Texas using data gathered after the model was developed using the technique described above. Frequency of SPB infestations in high risk classes on the Catahoula RD were two times greater than in medium risk classes and four times greater than in low risk classes (Lorio and Sommers 1981). On National Forest lands in Texas the frequency of SPB infestations in high risk classes was 1.3 times greater than in medium risk classes and approximately two times greater than in low risk classes (Lorio, Mason, and Autry 1982). Validation efforts have also been conducted for Mountain Risk. (Hedden 1980).

NF Ranger Districts maintain individual SPB spot records in cooperation with FPM after a District is funded for a SPB suppression project. Since 1985, this information has been placed on an Apple Computer. Records have been kept for 17 districts. Nine of these districts have kept stand information. These Districts are:

<u>Kistachie National Forest</u>
Catahoula RD
Evangeline RD

<u>National Forests in Mississippi</u>
Bienville RD
Bude RD
Strong River RD

<u>National Forests in Texas</u>
Neches RD
San Jacinto RD
Tenaha RD
Trinity RD

E. Initiate SPB Hazard Rating

Status of SPB Hazard Rating on National Forests

Chattahoochee - Oconee - Mountain Risk hazard rating system has been implemented on the Chattahoochee. The SPB hazard rating is being assigned by the prescriptionist at the time of the prescription. A compartment prescription handbook supplement has not been issued. On the Oconee & Piedmont sections of the Chattooga and Armuchee a modified version of National Forest Risk using CISC data has been implemented. FPM has completed stand hazard ratings for this area based on stand information gathered during an IPM demonstration project. A committment has been made that hazard rating will become part of the prescription process.

Sumter (Tyger & Enoree) - FPM has completed stand hazard ratings based on stand information gathered during an IPM demonstration project. FPM plans to extend this hazard rating system to other Piedmont Districts. No firm committment has been received for updating this data.

Francis-Marion - Nothing has been started. FPM hopes to be able to institute a hazard rating system developed by Dr. Roy Hedden for the coastal plain.

National Forests in Florida - No plans are in place to rate these Forests since SPB is seldom a problem.
George Washingtom
Jefferson
Ozark
National Forest in North Carolina

National Forests in Texas, National Forests in Miss. and Kisatchie National Forest - NF Risk based on CISC data has been implemented. Compartment Prescription Handbook supplements describing SPB hazard rating use in prescriptions have been issued.

Ouachita National Forest - FPM plans to work with SO to implement hazard rating. A particular system hasn't been selected but it will probably be a version of NF Risk.

National Forests in Alabama - NF Risk based on CISC data has been run. A committment has been made by the SO to implement hazard rating in prescriptions.

F. Silvicultural Treatments

A large percentage of the existing pine stands that are susceptible to the SPB resulted from natural seeding and planting on abandoned agricultural lands during the early 1900's. These stands grew rapidly but with little management. During these years demand for roundwood and small sawtimber was low. Very few stands were thinned when the need arose and as these stands grew older, they became crowded and vigor declined.

Today the percentage of land in pine plantations has increased over that which occurred several years ago. However, plantations can be just as susceptible to SPB attack as natural stands when poorly managed. Yet, both plantations and natural stands can be equally resistant to attack when silvicultural treatments are properly administered.

Systems have been developed to determine the relative susceptibility of stands to SPB attack and can be used to determine where cultural treatments can be applied to reduce SPB risk. Intermediate cuttings to reduce stocking levels and stimulate radial growth will lower the probability of attack in most high-risk stands. Response to cutting will not occur immediately after treatment. A period of 3 to 5 years may be necessary before roots and crowns of released trees can support rapid growth. Response time will increase with age of the stand and poor site quality. Overmature stands are usually past the point of physiological improvement and should be regenerated when possible.

Cultural treatments are also needed in young stands and low-risk stands to maintain rapid growing conditions. Competition in the stand usually occurs early in the life of the stand, depending on site quality and initial spacing. Initial thinning is recommended shortly after crown closure. The purpose of treating young stands is to prevent future high-risk conditions. Periodic thinning and improvement cuts will maintain stand vigor.

Silvicultural treatments should be reduced or eliminated when epidemic populations of SPB are present. Certain treatments can put temporary stress on treated stands which could increase their susceptibility to SPB attack.

Hardwood stands and inclusions should be encouraged where appropriate to help break up large pine stands.

G. Implement Rapid Control of All SPB Infestations on a Priority Basis.

The SPB is one of the most damaging and unpredictable pests of southern pine forests. Because of the sporadic nature of epidemics and the relatively long periods between epidemics, it is difficult to maintain a high level of consciousness of the potential damage that this pest can cause to the forest resource, as well as to the continuity of management.

Because the onset or collapse of epidemics cannot be predicted accurately with presently available knowledge of SPB biology and ecology, it is important that all known SPB activity (infestations) be noted, monitored, and where feasible, controlled to reduce the potential buildup of populations over time. The benefits of continuous attention to SPB are similar to the benefits gained with procedures used to reduce the potential occurrence of wildfires, the monitoring of them, and their control on a priority basis.

Work by Thatcher (1967, 1971, 1974) and Thatcher and Pickard (1964, 1967) in the West Gulf Coastal Plain showed that highest survival occurs in trees infested during the fall through early spring, that severity of outbreaks is greatest in the spring, and that survival and activity are lowest in the summer. Thatcher and Pickard (1964) recommended strongly that control be intensified in fall, winter, and spring, seasons in which control activities commonly are reduced considerably because new infestations are difficult to find and an apparent decline in SPB activity is perceived and undesirable site disturbances are associated with control.

Presumably, a lack of pheromones in the immediate vicinity of infestations allows long-range dispersion of beetles. Hedden and Billings (1977) found that average fat content and pronotal width of newly emerged adult beetles varied with season in east Texas, with fat content being highest in the fall and spring, and lowest in summer and winter. Beetles were smallest during July, August and September. Hedden and Billings suggest fat content is correlated with dispersal capacity, and that the abrupt decline in the number of new infestations detected in mid-summer indicates reduced beetle dispersal capacity. Further, they suggest that the long range dispersal of SPB in east Texas, followed by the initiation of new infestations, occurs primarily during the spring and fall when fat reserves are high, environmental conditions are optimal for flight, and intermittent cool weather interrupts pheromone production in old infestations.

Moser and Dell (1979) reported trapping large numbers of flying SPB in January, May and October of 1975, with peak catches occurring in October. In another study in 1978, more beetles were trapped in the first week in January than any other week of the year (Moser and Dell 1980). Beetles were caught in least numbers during very cold periods of January and February, and during the hot summer months.

Billings and Kibbe (1978) studied brood development in infestations in loblolly pine stands in several counties in southeast Texas from September 1976 through August 1977. They concluded that broods in winter-infested trees developed rapidly as temperatures rose in March and April, and that broods that took 17 weeks to develop from December 1 to April 1 emerged within a 5-week period of time from the last of April through the end of May.

Papers by Morris and Copony (1974) and Lorio and Bennett (1974) provide some evidence of the potential benefit of continuous, effective application of either rapid salvage or direct chemical control in reducing losses to the SPB. Morris and Copony's study covered a period of one year and Lorio and Bennett's study covered a period of five years. In both cases the results indicated that SPB populations were affected significantly. Morris and Copony reported a 30 percent decrease in spots per M acres with intensive salvage and about a 30 percent increase on the check area. Lorio and Bennett reported that the nearly 3000 infestations treated in their study averaged only 3.4 trees per infestation, and that in spite of very intensive application of chemical control of the infestations, an uncontrollable epidemic did not occur. These results contrast with reports by Williamson (1971) and Williamson and Vite' (1971) who concluded that chemical control actually dispersed SPB populations and encouraged epidemics in east Texas in the 1960's.

Billings (1979) suggests that in nonepidemic years it may be advisable to detect small-sized infestations and determine the need for control. Lorio (1984) pointed out that volume losses in small infestations could be considerable if the spots occurred in large diameter stands. He further states that the potential for reproducing SPB in large sawtimber is high, and that control of small infestatons in such stands during endemic periods would help prevent the build-up of SPB populations that leads to uncontrollable outbreaks.

Recent application of knowledge on growth and differentiation balance relationships in plants to understanding interactions between the SPB and its host trees indicates that the general population of trees will be quite susceptible to beetle attack in the fall, winter, and spring (Lorio and Hodges 1985, Lorio 198_). Normal changes in host physiology associated with the seasonal development of trees indicates that in the absence of severe drought, pines would be most resistant to beetle attack during the summer.

Lorio and Sommers (198_) report that preliminary tests with loblolly pine strongly support application of growth-differentiation balance relationships as described here, and its use as a basic principle for design of future research.

If one accepts the idea that the general population of pines will be quite susceptible to SPB attack for much of the year, not considering the further possible effects of overstocking, old age, disturbances, severe drought, etc., then the need for consistent, continuous, rapid control of all known SPB infestations on a priority basis is strongly indicated.

H. Log Storage

During September of 1985, a team studied the methods and feasibility of storing beetle-killed timber. Their conclusion in the "Report of Log Storage Work Group on Feasibility of Water Storage of Beetle-Killed Timber" follows.

"While it is technically feasible to store beetle-killed southern yellow pine sawlogs it does not appear to be economically feasible. A change in logging cost or estimated log sale prices could change the results of this analysis. Consideration of non-direct benefits such as reduction in fire hazard due to reduced fuel levels and public opinion of cut-and-leave operations might also influence a final decision. Based on present cost assumptions and considering only direct cost it does not appear to be economically feasible to store beetle-killed pine logs".

I. Record Keeping

Since 1978, a computerized record keeping system, the Southern Pine Beetle Information System (SPBIS), has been used to document SPB losses for National Forest Ranger Districts which have funded SPB suppression projects.

From 1979-1982 this information was entered on the USDA Forest Service computing facility at Fort Collins, Colorado. Since Districts did not have direct access to this facility the data were used predominately for historical information and post-suppression evaluations. In 1983 an IPM demonstration project funded by the IPM program was conducted on the Holly Springs NF in Mississippi. During this project, the SPB data collected during a suppression project were modified and the program was revised to run on an Apple computer. Therefore, since 1983 Districts having a SPB suppression project have been provided an Apple computer. Districts have been able to both enter data and have immediate access to the data. Programs have been written which provide accomplishment summaries and prioritize spots for control. While this system has greatly enhanced SPB control efforts there are no data requirements for Districts which do not have SPB suppression projects.

Continuous monitoring of SPB activity would provide information to identify the level of SPB activity in high hazard stands and would document increases in SPB activity so Districts could respond before populations reach epidemic levels.

Appendix A

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Appendix B

TABLE 1. - GUIDE TO SOUTHERN PINE BEETLE SPOT GROWTH AND CONTROL PRIORITIES (MAY THROUGH OCTOBER)

Key to spot growth	Your spot's classification	Risk-Rating Points
A. Fresh Attacks	absent	0
	present	30
B. Number of freshly attacked trees and and those with developing brood	1-10	0
	11-20	10
	21-50	20
	more than 50	40
C. Pine basal area (or stand density) at active head(s) (ft^2/acre)	less than 80 (low density)	0
	80-120 (medium density)	10
	more than 120 (high desnisty)	20
D. Average size class of timber (in inches)	pulpwood (9 inches or less)	0
	sawtimber (more than 9 in.)	10

Add up the risk-rating points that apply to your spot.

Score	Control priority
0-30	Low
40-60	Medium
70-100	High

Appendix C

SOUTHERN PINE BEETLE ORGANIZATION

(SO LEVEL)

- SO Coordinator
  - Clerical
  - Public Information Coordinator
  - Safety/Training Specialists
  - Planning Officer
    - Computer/Data Base Coordinator SPBIS - DSS
    - Other Technical Specialists
    - Wildlife Coordinator
  - Resource Operations
    - Clerical
    - Wilderness Coordinator
    - Salvage Sale Coordinator
    - Cut-and-Leave Coordinator
    - Air Operations Coordinator
  - Administrative Coordinator
    - Clerical
    - Personnel Specialist
    - Budget/Finance Officer
      - Purchasing/Procurement Personnel
      - Payment Process Clerical Personnel
  - Logistics Coordinator
    - Clerical
    - Vehicle Coordinator
    - Detail Dispatcher
    - Communi- cations Specialist

Appendix D

SPB SUPPRESSION ORGANIZATION

(DISTRICT LEVEL)

SPB Coordinator

- SPBIS
- Administrative Support
- Vehicle Coordinator
- Safety Officer
- **Zone Coordinator** (For each 500 spots)
  - Direct Control
  - Salvage Sales
  - Detection Ground Surv. Post Checks
  - Wilderness

Detection Ground Survey & Post Checks

- Observers
- Ground Survey Crew(s)
- Post Check Crew(s)

Salvage Sales

- Sales Admin.
- Marking Crews
- Ticket Givers

Direct Control

- Tractor Operation Boss
- Marking Crews
- Felling COR/Insp.

Wilderness

- Ground Survey Post Checks
- Documentation
- Spot Watchers or Sale Admin.

Appendix E

ACTION - RECOMMENDED TOURS FOR DETAILERS

Tour	**Skills Needed**
3 weeks minimum 4 weeks ideal	Timber Marker - (certified)
4 weeks minimum	Sale Administrator - (experienced)
2 weeks minimum 4 weeks ideal	Spot Watcher - (if required)
4 weeks minimum	Professionals - TMA, silviculturist preferred
4 weeks minimum	COR - (certified)
4 weeks minimum	Post checkers (breakout) - Forestry Tech. w/marking experience
4 weeks minimum	Ground Scouts - Forestry Tech.
2 weeks minimum 4 weeks ideal	Tractor Optr-FS license to operate equipment
2 weeks minimum	SSS (BMA) - experienced
2 weeks minimum	Compliance Inspectors - experienced, marking experience.
2 weeks minimum	Chainsaw Operator - (certified)
2 weeks minimum	Clerks - experienced Timekeepers Timber sale clerks